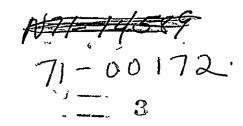
/m?



MCR-70-457 (Vol I)

## FINAL REPORT

## SPIN VECTOR CONTROL FOR A SPINNING SPACE STATION

VOLUME I: USER'S MANUAL

By:

- T. Hendricks
- W. Guderian
- G. Johnson
- G. Haynes

November 1970

Prepared under Contract No. NAS8-25247 by

MARTIN MARIETTA CORPORATION
Denver Division
P. O. Box 179
Denver, Colorado 80201

for

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812

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NATIONAL TECHNICAL INFORMATION SERVICE Springfield, Va. 22151

# FOREWORD

This document represents Volume II of the final report on NASA Huntsville Contract entitled "Spin Vector Control for a Spinning Space Station". The report is prepared in two volumes:

Volume I - User's Manual

Volume II - Analytical Manual

## FINAL REPORT

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#### FINAL REPORT

SPIN VECTOR CONTROL OF A ROTATING SPACE STATION

VOLUME I: USER'S MANUAL

By: T. Hendricks, Walter Guderian, George Haynes, Gary John'son

# SUMMARY

This document presents the formulation, computational logic, input/output options, subroutine description and other pertinent information that should aid the user of the SPIN VECTOR CONTROL COMPUTER PROGRAM (MD246).

#### I. INTRODUCTION

This document is concerned with the design use and implementation of a digital computer program to facilitate the study of the dynamic behaviour and control of dual spin space vehicles. This volume is a companion to Volume II (analytical manual) of the final report under NASA-Huntsville Contract NASS-25247.

The Spin Vector Control Program (MD246) is a Fortran

Program that was written and checked out using the CDC 6400/

6500 digital computer. To minimize possible system incompatabilities care has been exercised to assume that only the basic features of the system are used. Thus the program should be

operable on most digital machines with a FORTRAN 4 compiler.

The program is capable of solving the rotational dynamics of dual spin earth orbiting spacecraft. Several control options as well as spacecraft configurations are possible.

Among the available control actuators are CMGs, reaction wheels, reaction jets and torque motors. This program is intended for but not restricted to attitude control studies of a rotating space station. The generalized spacecraft configuration along with geometrical definitions is shown in Figure 1. Figure 2 is a specific spacecraft configuration.

The remaining contents of this document discusses in varying degree of detail how to use the program. The first chapter Input Deck Construction describes those cards which are necessary when exercising the various program options.

Chapter 2 Data Deck User's Guide presents a complete sequence and format description of all the data input cards. For a description and definition of the input variables refer to Appendix A.

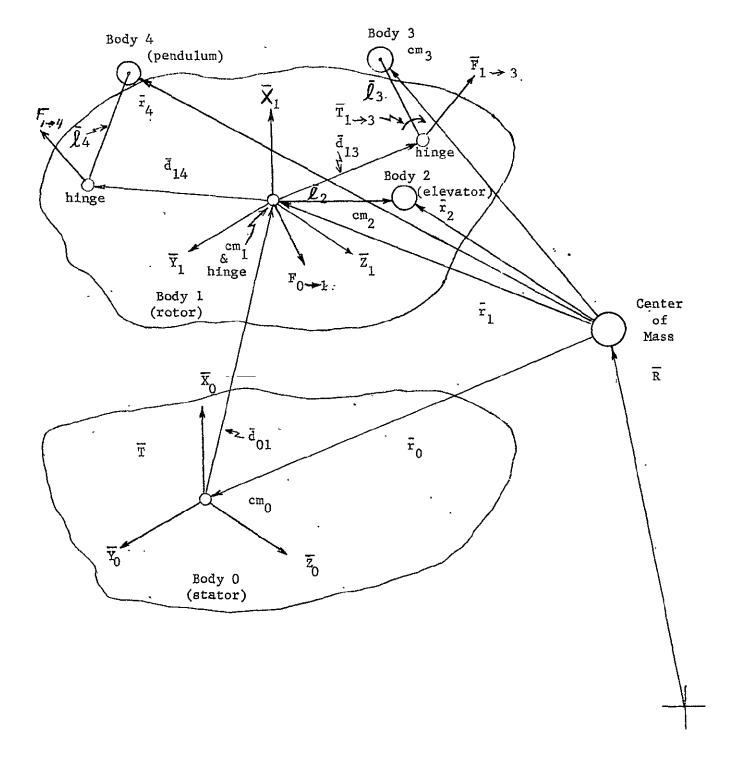


Figure 1 General Body Configuration

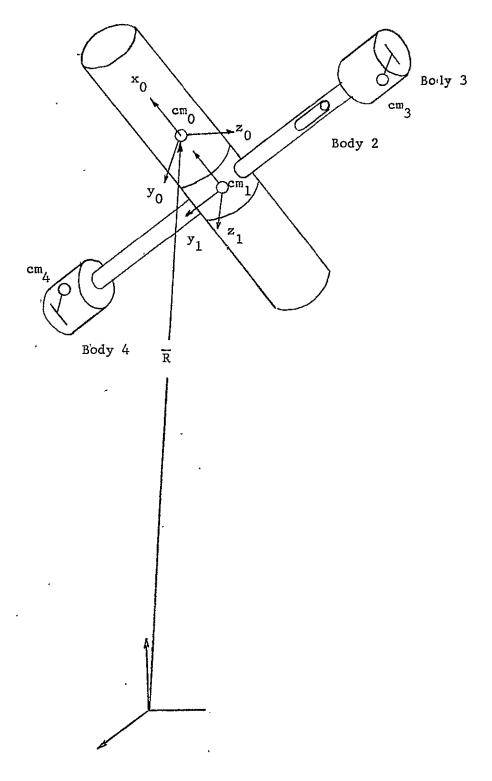


Figure 2 Spacecraft Body Configuration

# INPUT DECK CONSTRUCTION

The basic data deck for operating the program with essentially no designated options is as follows.

Card ;	Variable					
1	NDECK =					
2	IPNDLM = 0	First	card	of	run	data
3	IPRINT =					•
4	TSTART, TSTOP, DELTAT					
5	Alt.					•
6-14	TIBOI(1,1) - TIBOI(3,3)					
15	WO(1), WO(2), WO(3)					
16	BOMASS					
17-25	BODYOI(1,1) - BODYOI(3,3)					
26	NUMCMG = 0					
225	IPROPF = 0	1				
242	Blmass					
ু 243–251	BODY11(1,1) - BODY11(3,3)					
252	THETAI					
253	OMEGA1					
<b>254</b>	DO1(1), DO1(2), DO1(3)					
255	IB2F = 0					
282	SP					
283	NGAIN = 0					
294	IGRAVF = 0					
295	IDOCK = 0					

Note that the above is also a list of the cards that must always be present.

Some examples of data deck arrangements for various options will be given. All data decks consist of the basic data deck with changes indicated.

#### 1. Pendulum

Card #2 IPNDLM = 1

Before card #282 add cards #268 through #281, the pendulum parameter and initial value data.

# 2. Two single DOF CMGs

Card #26 NUMCMG = 2

After card #26 add -

Card 
$$#27$$
 IDOF(1) = 1

#28 - HW(1)

#29 - #37 AOCJ(1,1,1) - AOCJ(1,3,3)

#38 - #42 AII(1,1,1) - AII(1,3,3)

#47 - THATA(1)

#48 - THATAD(1)

#60 - IDOF(2) = 1

#61 - HW(2)

#62 - #70 AOCJ(2,1,1) - AOCJ(2,3,3)

#71 - #79 AII(2,1,1) - AII(2,3,3)

#80 - THATA(2)

#81 - THATAD(2)

Card #283 NGAIN = 5

After card #283 add cards #284 - #288

(Cards #287 is control gain for CMG #1 and card #288 is control gain for CMG #2 in the present subroutines)

3. Propulsion on Body 0 (no attitude control)
Card #225 IPROPF = 1

After card #225 add -

Cárd #226 IATTIF = 0

Card #230 AOJ(1) = (non-zero) CGAINO(1)

Card #231 AOJ(2) = (non-zero) CGAINO(2)

Card #232 AOJ(3) = (non-zero) CGAINO(3)

After card #259, if present, otherwise after card #255 add -

Card #260 AlJ(1) = (non-zero) CGAIN1(1) = 0

Card #261 AlJ(2) = (non-zero) CGAIN( $\hat{2}$ ) = 0

4. Movable Mass

Card #255 IB2F = 1

After card #255 add cards #256 - #259 pertaining to movable mass 5. Attitude Control with Propulsion on Body 1
Card #225 IPROPF = 1

After card #225 add -

Card #226 IATT1F = 1

Card #227 CA(1), CA(2), CA(3)

Card #230 AOJ(1) = (non-zero) CGA(N(1) = 0

Card #231 AOJ(2) = (non-zero) CGAIN(2) = 0

Card #232 AOJ(3) = (non-zero) CGAlN(3) = 0

After card #259 if present, otherwise after card #255 add -

Card #260 AlJ(1) = (non-zero) CGA N1(1)

Card #261 AlJ(2) = (non-zero) CGA(N1(2)

6. Gravity Gradient

Card #294 IGRAVF = 1

7. Docking

Card #295 IDOCK = 1

After card #295 add cards #296 - =307 docking quantities.

## DATA DECK USER'S GUIDE

```
/c vad: 5
       I ISTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
       VARIABLE: ALT
      FORMAT: + . E+
COLUMN: 2 3 4 5 6 7 8 9 10 11 12
     CARD: 4
     INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
     VARIABLES: TSTART
                               TSTOP
                                              DELTAT
     - 28 29 30 31 32 33 34 35 36 37 38
   CARD: 3
   INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
   VARIABLE: IPRINT
   FORMAT:
   COLUMN:
 CARD: 2
  INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
 VARIABLE: IPNDLM
 FORMAT:
 COLUMN:
CARD: 1
INSTRUCTION: THIS CARD GOES-IN FRONT OF DATA DECK 1 ONLY.
VARIABLE: NDECK
FORMAT:
COLUMN: 21
```

```
CARD: 14
           VARIABLE: TIBOI (3,3)
         CARD: 13
         VARIABLE: TIBOI (3,2)
        CARD: 12
        VARIABLE: TIBOI (3,1)
       CARD: 11
       VARIABLE: TIBOI (2,3)
      CARD: 10
      VARIABLE: TIBOI (2,2)
      CARD: 9.
     VARIABLE: TIBOI (2,1)
     CARD: 8
    VARIABLE: TIBOI (1,3)
    CARD: 7
   VARIABLE: TIBOI (1,2)
CARD: 6
INSTRUCTION: THE NEXT 9 CARDS MUST ALWAYS BE PRESENT.
VARIABLE: TIBOI (1,1)
FORMAT: +
COLUMN: 23454188101112
```

```
CARD: 16
INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
VARIABLE: BOMASS
FORMAT: + . E+
COLUMN: 23455745100112

CARD: 15
INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
VARIABLES: WO(1) WO(2) WO(3)
FORMAT: + . + . + . . + .

23456745100112 B161083221222242 22320.12233455573
```

```
CARD: 25
           VARIABLE: BODYOI (3,3)
         CARD: 24
         VARIABLE: BODYOI (3,2)
         CARD: 23
        VARIABLE: BODYOI (3,1)
        CARD: 22
       VARIABLE: BODYOI (2,3)
      CARD: 21
     · VARIABLE: BODYOI (2,2)
      CARD: 20
     VARIABLE: BODYOI (2,1)
     CARD: 19
    VARIABLE: BODYOI (1,3)
    CARD: 18
   VARIABLE: BODYOI (1,2)
CARD: 17
INSTRUCTION: THE NEXT 9 CARDS MUST ALWAYS BE PRESENT.
VARIABLE: BODYOI (1,1)
FORMAT:
          ±.
                E++
COLUMN:
          234567881011121
```

```
CARD: 28

INSTRUCTION: IF NUMCMG = 0, IGNORE THIS CARD.

VARIABLE: HW (1)

FORMAT: ± . E±

COLUMN: 23455; 2919112

CARD: 27

INSTRUCTION: IF NUMCMG = 0, IGNORE THIS CARD.

VARIABLE: IDOF (1)

FORMAT:

COLUMN: 3

CARD: 26

INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.

VARIABLE: NUMCMG

FORMAT:

COLUMN: 3
```

```
CARD: 37
          VARIABLE: AOCJ (1,3,3)
        CARD: 36
        VARIABLE: AOCJ (1,3,2)
        CARD: 35
       VARIABLE: AOCJ (1,3,1)
       CARD: 34
       VARIABLE: AOCJ (1,2,3)
      CARD: 33
      VARIABLE: AOCJ (1,2,2)
     CARD: 32
     VARIABLE: AOCJ (1,2,1)
    CARD: 31
    VARIABLE: AOCJ (1,1,3)
   CARD: 30
   VARIABLE: AOCJ (1,1,2)
                                                           . !
CARD: 29
INSTRUCTION: IF NUMCMG = 0, IGNORE THE NEXT 9 CARDS.
VARIABLE: AOCJ (1,1,1)
         2 3 4 5 8 7 8 8 10 11 12
FORMAT:
COLUMN:
```

```
CARD: 46
           VARIABLE: AII (1,3,3)
          CARD: 45
          VARIABLE: AII (1,3,2)
         CARD: 44
         VARIABLE: AII (1,3,1)
        CARD: 43
        VARIABLE: AII (1,2,3)
       CARD: 42
       VARIABLE: AII (1,2,2)
      CARD: 41
      VARIABLE: AII (1,2,1)
     CARD: 40
     VARIABLE: AII (1,1,3)
    CARD: 39
    VARIABLE: AII (1,1,2)
CARD: 38
INSTRUCTION: IF NUMCMG OR IDOF (1) = 0, IGNORE THE NEXT 9 CARDS.
VARIABLE: AII (1,1,1)
FORMAT:
COLUMN:
          2 3 4 5 8 7 8 9 10 11 12
```

```
CARD: 48
VARIABLE: THATAD (1)
FORMAT: + .
COLUMN: 7,345,678,810,112

CARD: 47
INSTRUCTION: IF NUMCMG OR IDOF (1) = 0, IGNORE THE NEXT 2 CARDS.
VARIABLE: THATA (1)
FORMAT: + .
COLUMN: 2,345,678,910,117
```

```
CARD: 57
          VARIABLE: AIO (1,3,3)
         CARD: 56
         VARIABLE: AIO (1,3,2)
         CARD: 55
        VARIABLE: AIO (1,3,1)
        CARD: 54
       VARIABLE: AIO (1,2,3)
       CARD: 53
      VÄRIABLE: AIO (1,2,2)
      CARD: 52
     VARIABLE: AIO (1,2,1)
     CARD: 51
    VARIABLE: AIO (1,1,3)
    CARD: 50
   VARIABLE: AIO (1,1,2)
CARD: 49
INSTRUCTION: IF NUMCMG = 0, OR IDOF (1) = 0, OR IDOF (1) = 1, IGNORE THE NEXT 9 CARDS.
VARIABLE: AIO (1,1,1)
          ± 2,3,4 5.6 7 8,9 10,11 12,
FORMAT:
COLUMN:
```

```
CARD: 61
        INSTRUCTION: IF NUMCMG < 2, IGNORE THIS CARD.
        VARIABLE: HW (2)
                    ± . E±
        FORMAT:
        COLUMN:
                    2 3 4 5 6 7 8 9 10 11 12
      CARD: 60
     INSTRUCTION: IF NUMCMG < 2, IGNORE THIS CARD.
     VARIABLE: IDOF (2)
      FORMAT:
     COLUMN: 3
   CARD: 59
   VARIABLE: FEED (1)
   FORMAT: + ... COLUMN: 23455789101112
CARD: 58
INSTRUCTION: IF NUMCMG = 0, OR IDOF (1) = 0, OR IDOF (1) = 1, IGNORE THE NEXT 2 CARDS.

VARIABLE: FEE (1)
VARIABLE: FEE (1)
FORMAT: <u>+</u> ... COLUMN: 2 3 4 5 8 7 5 9 10 11 12
```

```
CARD: 70
           VARIABLE: AOGJ (2,3,3)
          CARD: 69
          VARIABLE: AOCJ (2,3,2)
         CARD: 68
         VARIABLE: AOCJ (2,3,1)
        CARD: 67
        VARIABLE: AOCJ (2,2,3)
       CARD: 66
       VARIABLE: ACCJ (2,2,2)
      CARD: 65
      VARIABLE: AOCJ (2,2,1)
     CARD: 64
     VARIABLE: AOCJ (2,1,3)
    CARD: 63
    VARIABLE: AOCJ (2,1,2)
CARD: 62
INSTRUCTION: IF NUMCMG < 2, IGNORE THE NEXT 9 CARDS.
VARIABLE: AOCJ (2,1,1)
          ± 2.3 4 5 6 7 8 9 10 11 12
FORMAT:
COLUMN:
```

```
CARD: 79
            VARIABLE: AII (2,3,3)
           CARD: 78
           VARIABLE: AII (2,3,2)
          CARD: 77
         VARIABLE: AII (2,3,1)
         CARD: 76
        VARIABLE: AII (2,2,3)
        CARD: 75
        VARIABLE: AII (2,2,2)
       CARD: 74
      VARIABLE: AII (2,2,1)
      CARD: 73
      VARIABLE: AII (2.1.3)
     CARD: 72
     VARIABLE: AII (2,1,2)
CARD: 71
INSTRUCTION: IF NUMCMG < 2, OR IDOF (2) = 0, IGNORE THE NEXT 9 CARDS.
VARIABLE: AII (2,1,1)
FORMAT:
COLUMN:
          2 3 4 5 6 7 8 9 10 11 12
1
```

```
CARD: 81
INSTRUCTION: IF NUMCMG < 2, OR IDOF (2) = 0, IGNORE THIS CARD.
VARIABLE: THATAD (2)
FORMAT: +
COLUMN: 2345676610112

CARD: 80
INSTRUCTION: IF NUMCMG < 2, OR IDOF (2) = 0, IGNORE THIS CARD.
VARIABLE: THATA (2)
FORMAT: +
COLUMN: 2345676510112
```

```
CARD: 90
            VARIABLE: AIO (2,3,3)
           CARD: 89
           VARIABLE: AIO (2,3,2)
          CARD: 88
          VARIABLE: AIO (2,3,1)
         CARD: 87
         VARIABLE: AIO (2,2,3)
        CARD: 86
        VARIABLE: AIO (2,2,2)
       CARD: 85
       VARIABLE: AIO (2,2,1)
      CARD: 84
      VARIABLE: AIO (2,1,3)
     CARD: 83
     VARIABLE; AIO (2,1,2)
CARD: 82
INSTRUCTION: IF NUMCMG < 2, OR IDOF (2) = 0, OR IDOF (2) = 1,
             IGNORE THE NEXT 9 CARDS.
VARIABLE: AIO (2,1,1)
          2 3 4 5 8 7 8 9 10 11 12
FORMAT:
COLUMN:
```

```
CARD: 103
           VARIABLE: AOCJ (3,3,3)
          CARD: 102
          VARIABLE: AOCJ (3,3,2)
         CARD: 101
         VARIABLE: AOCJ (3,3,1)
        CARD: 100
        VARIABLE: AOCJ (3,2,3)
       CARD: 99
       VARIABLE: AOCJ (3,2,2)
      CARD: 98
      VARIABLE: AOCJ (3,2,1)
     CARD: 97
     VARIABLE: AOCJ (3,1,3)
    CARD: 96
    VARIABLE: AOCJ (3,1,2)
CARD: 95
INSTRUCTION: IF NUMCMG < 3, IGNORE THE NEXT 9 CARDS.
VARIABLE: AOCJ (3,1,1)
          <u>+</u> '
FORMAT:
COLUMN:
          2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 112
           VARIABLE: AII (3,3,3)
          CARD: 111
          VARIABLE: AII (3,3,2)
         CARD: 110
       · VARIABLE: AII (3,3,1)
        CARD: 109
        VARIABLE: AII (3,2,3)
       CARD: 108
       VAR (ABLE: AII (3,2,2)
      CARI: 107
      VARIABLE: AII (3,2,1)
     CARD: 106
     VARIABLE: AII (3,1,3)
    CARD: 105
    VARIABLE: AII (3,1,2)
CARD: 104
INSTRUCTION: IF NUMCMG < 3, OR IDOF (3) = 0,
            IGNORE THE NEXT 9 CARDS.
VARIABLE: AII (3,1,1)
FORMAT:
COLUMN:
          2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 114
INSTRUCTION: IF NUMCMG < 3, OR IDOF (3) = 0, IGNORE THIS CARD.
VARIABLE: THATAD (3)
FOFMAT: ±
COI UMN: 2345678910112

CARD: 113
INSTRUCTION: IF NUMCMG < 3, OR IDOF (3) = 0, IGNORE THIS CARD.
VARIABLE: THATA (3)
FORMAT: ±
COLUMN: 2345678910112
```

```
CARD: 123
           VARIABLE: AIO (3,3,3)
         CARD: 122
         VARIABLE: AIO (3,3,2)
        CARD: 121
        VARIABLE: AIO (3,3,1)
       CARD: 120
       VARIABLE: AIO (3,2,3)
      CARD: 119
      VARIABLE: AIO (3,2,2)
     CARD: 118
     VARIABLE: AIO (3,2,1)
     CARD: 117
    VARIABLE: AIO (3,1,3)
    CARD: 116
   VARIABLE: AIO (3,1,2)
CARD: 115
INSTRUCTION: IF NUMCMG < 3, OR IDOF (3) = 0, OR IDOF (3) = 1,
             IGNORE THE NEXT 9 CARDS.
VARIABLE: AIO (3,1,1)
FORMAT: : ±
COLUMN:
         2 3 4 5 8 7 8 8 10 11 12
```

```
CARD: 127
       INSTRUCTION: IF NUMCMG < 4, IGNORE THIS CARD.
       \ARIABLE: HW (4)
       FORMAT: ± . E+
     COLUMN:
CARD: 126
                   ____ 2_3_4 5_6 7 8 9 10 II 12 ___
     INSTRUCTION: IF NUMCMG < 4, IGNORE THIS CARD. VARIABLE: IDOF (4)
     FORMAT:
     COLUMN:
   CARD: 125
   VARIABLE: FEED (3)
CARD: 124
INSTRUCTION: IF NUMCMG < 3, OR IDOF (3) = 0, OR IDOF (3) = 1, IGNORE THE NEXT 2 CARDS.
VARIABLE: FEE (3)
FORMAT:
COLUMN:
            2 3 4 5 8 7 8 9 10 11 12
```

```
CARD: 136
          VARIABLE: AOCJ (4,3,3)
        CARD: 135
        VARIABLE: AOCJ (4,3,2)
       CARD: 134
       VARIABLE: AOCJ (4,3,1)
       CARD: 133
      VARIABLE: AOCJ (4,2,3)
      CARD: 132
     VARIABLE: AOCJ (4,2,2)
     CARD: 131
     VARIABLE: AOCJ (4,2,1)
    CARD: 130
    VARIABLE: AOCJ (4,1,3)
   CARD: 129
   VARIABLE: AOCJ (4,1,2)
CARD: 128
INSTRUCTION: IF NUMCMG < 4, IGNORE THE NEXT 9 CARDS.
VARIABLE: AOCJ (4,1,1)
FORMAT: ± .
COLUMN: 2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 145
         VARIABLE: AII (4,3,3)
        CARD: 144
        VARIABLE: AII (4,3,2)
       CARD: 143
       VARIABLE: AII (4,3,1)
       CARD: 142
      VARIABLE: AII (4,2,3)
      CARD: 141
     VARIABLE: AII (4,2,2)
     CARD: 140
     VARIABLE: AII (4,2,1)
    CARD: 139
    VARIABLE: AII (4,1,3)
   CARD: 138
   VARIABLE: AII (4,1,2)
CARD: 137
INSTRUCTION: IF NUMCMG < 4, OR IDOF (4) = 0,
          IGNORE THE NEXT 9 CARDS.
VARIABLE: AII (4,1,1)
FORMAT: ±
COLUMN: 2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 147
INSTRUCTION: IF NUMCMG < 4, OR IDOF (4) = 0, IGNORE THIS CARD.
VARIABLE: THATA (4)
FORMAT: 
COLUMN: 23458788101112

CARD: 146
INSTRUCTION: IF NUMCMG < 4, OR IDOF (4) = 0, IGNORE THIS CARD.
VARIABLE: THATA (4)
FORMAT: 
COLUMN: 23458789101112
```

```
CARD: 156
         VARIABLE: AIO (4,3,3)
        CARD: 155
       VARIABLE: AIO (4,3,2)
       CARD: 154
       VARIABLE: AIO (4,3,1)
      CARD: 153
      VARIABLE: AIO (4,2,3)
     CARD: 152
     VARIABLE: AIO (4,2,2)
    CARD: 151
    VARIABLE: AIO (4,2,1)
    CARD: 150
    VARIABLE: AIO (4.1.3)
   CARD: 149
   VARIABLE: AIO (4,1,2)
CARD: 148
INSTRUCTION: IF NUMCMG < 4, OR IDOF (4) = 0, OR IDOF (4) = 1,
          IGNORE THE NEXT 9 CARDS.
VARIABLE: AIO (4,1,1)
```

```
CARD: 160
       INSTRUCTION: IF NUMCMG < 5, IGNORE THIS CALD.
       VARÍABLE: HW (5)
FORMAT: +
                            王十
        COLUMN:
                    2 3 4 5 6 7 8 9 10 11 12
     CARD: 159
     INSTRUCTION: IF NUMCMG < 5, IGNORE THIS CARD. VARIABLE: IDOF (5)
     FORMAT:
     COLUMN:
   CARD: 158
   VARIABLE: FEED (4)
CARD: 157
INSTRUCTION: IF NUMCMG < 4, OR IDOF (4) = 0, OR IDOF (4) = 1,
                IGNORE THE NEXT 2 CARDS.
VARIABLE: FEE (4)
FORMAT:
            <u>+</u>
COLUMN:
            2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 169
        VARIABLE: AOCJ (5,3,3)
       CARD: 168
       VARIABLE: AOCJ (5,3,2)
       CARD: 167
       VARIABLE: AOCJ (5,3,1)
      CARD: 166
      V/RIABLE: AOCJ (5,2,3)
     CARD: 165
     VARIABLE: AOCJ (5,2,2)
     CARD: 164
    VARIABLE: AOCJ (5,2,1)
    CARD: 163
    VARIABLE: AOCJ (5,1,3)
   CARD: 162
   VARIABLE: AOCJ (5,1,2)
CARD: 161
INSTRUCTION: IF NUMCMG < 5, IGNORE THE NEXT 9 CARDS.
VARIABLE: AOCJ (5,1,1)
FORMAT:
COLUMN:
       2.3 4 5 6 7 8 9 10 11 12
```

```
CARD: 178
           VARIABLE: AII (5,3,3)
          CARD: 177
         VARIABLE: AII (5,3,2)
         CARD: 176
         VARIABLE: AII (5,3,1)
        CARD: 175
        VARIABLE: AII (5,2,3)
       CARD: 174
       VARIABLE: AII (5,2,2)
      CARD: 173
      VARIABLE: AII (5,2,1)
     CARD: 172
     VARIABLE: AII (5,1,3)
    CARD: 171
    VARIABLE: AII (5,1,2)
CARD: 170
INSTRUCTION: IF NUMCMG < 5, OR IDOF (5) = 0,
            IGNORE THE NEXT 9 CARDS.
VARIABLE: AII (5,1,1)
FORMAT: +
COLUMN:
        2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 180
INSTRUCTION: IF NUMCMG < 5, OR IDOF (5) = 0, IGNORE THIS CARD.
VARIABLE: THATAD (5)
FORMAT: +
COLUMN: 23.455789101112

CARD: 179
INSTRUCTION: IF NUMCMG < 5, OR IDOF (5) = 0, IGNORE THIS CARD.
VARIABLE: THATA (5)
FORMAT: +
COLUMN: 23.455789101112
```

```
CARD: 189
          VARIABLE: AIO (5,3,3)
         CARD: 188
         VARIABLE: AIO (5,3,2)
        CARD: 187
        VARIABLE: AIO (5,3,1)
       CARD: 186
       VARIABLE: AIO (5,2,3)
       CARD: 185
      VARIABLE: AIO (5,2,2)
      CARD: 184
      VARIABLE: AIO (5,2,1)
     CARD: 183
     VARIABLE: AIO (5.1.3)
    CARD: 182
    VARIABLE: AIO (5,1,2)
CARD: 181
INSTRUCTION: IF NUMCMG < 5, OR IDOF (5) = 0, OR IDOF (5) = 1,
           IGNORE THE NEXT 9 CARDS.
VARIABLE: AIO (5,1,1)
FORMAT:
COLUMN:
       2 3 4 5 E 7 8 9 10 11 12
```

```
CARD: 193
INSTRUCTION: IF NUMCMG < 6, IGNORE THIS CARD.
VARIABLE: HW (6)
FORMAT: + . E+
       COLUMN:
                    2 3 4 5 6 7 8 9 10 11 12
     CARD: 192
     INSTRUCTION: IF NUMCMG < 6, IGNORE THIS CARD.
     VARIABLE: IDOF (6)
     FORMAT:
     COLUMN:
   CARD: 191
   VARIABLE: FEED (5)
CARD: 190
INSTRUCTION: IF NUMCMG < 5, OR IDOF (5) = 0, OR IDOF (5) = 1
               IGNORE THE NEXT 2 CARDS.
VARIABLE: FEE (5)
FORMAT:
COLUMN:
            2 3 4 5 6 7 8 9 19 11 12
```

```
CARD: 202
         VARIABLE: AOCJ (6,3,3)
        CARD: 201
        VARIABLE: AOCJ (6,3,2)
       CARD: 200
       VARIABLE: AOCJ (6,3,1)
      CARD: 199
      VARIABLE: AOCJ (6,2,3)
      CARD: 198
     VARIABLE: AOCJ (6,2,2)
     CARD: 197
     VARIABLE: AOCJ (6,2,1)
    CARD: 196
    VARIABLE: AOCJ (6,1,3)
   CARD: 195
   VARIABLE: AOCJ (6,1,2)
CARD: 194
INSTRUCTION: IF NUMCMG < 6, IGNORE THE NEXT 9 CARDS.
VARIABLE: AOCJ (6,1,1)
FORMAT:
COLUMN: 2 3 4 5 5 7 8 9 10 11 12
```

```
CARD: 211
           VARIABLE: AII (6,3,3)
          CARD: 210
         VARIABLE: AII (6,3,2)
         CARD: 209
         VARIABLE: AII (6,3,1)
        CARD: 208
        VARIABLE: AII (6,2,3)
       CARD: 207
       VARTABLE: AII (6,2,2)
      CARD: 206
      VARIABLE: AII (6,2,1)
     CARD: 205
     VARIABLE: AII (6,1,3)
    CARD: 204
    VARIABLE: AII (6,1,2)
CARD: 203
INSTRUCTION: IF NUMCMG < 6, OR IDOF (6) = 0,
             IGNORE THE NEXT 9 CARDS.
VARIABLE: AII (6,1,1)
FORMAT:
          2 3 4 5 8 7 8 9 10 11 12
COLUMN:
```

```
CARD: 222
VARIABLE: AIO (6,3,3)
         CARD: 221
         VARIABLE: AIO (6,3,2)
        CARD: 220
        VARIABLE: AIO (6,3,1)
        CARD: 219
        VARIABLE: AIO (6,2,3)
       CARD: 218
       VARIABLE: AIO (6,2,2)
      CARD: 217
      VARIABLE: AIO (6,2,1)
     CARD: 216
     VARIABLE: AIO (6,1,3)
    CARD: 215
    VARIABLE: AIO (6,1,2)
CARD: 214
INSTRUCTION: IF NUMCMG < 6, OR IDOF (6) = 0, OR IDOF (6) = 1,
            IGNORE THE NEXT 9 CARDS.
VARIABLE: AIO (6,1,1)
FORMAT:
         2 3 4 5 6 7 8 9 10 11 12
COLUMN:
```

DUE TO MODIFICATIONS, THE NEXT DATA CARD HAS THE NUMBER 230.

```
CARD: 227
          INSTRUCTION: IF IPROPF OR LATTIF = 0, IGNORE THIS CARD. VARIABLES: CA(1) CA(2) CA(3)
          FORMAT:
          COLUMN:
                          2 3 4 5 6 7 8 9 19 11 12 <u></u>
                                                                  __ 28 29 30 31 32 33 34 35 36 37 38 <u>_</u>
                                             <u>__ 15 16 17 18 19 20 21 22 23 24 25_</u>
        CARD: 226
        INSTRUCTION: IF IPROPF = 0, IGNORE THIS CARD. VARIABLE: IATTIF
        FORMAT:
        COLUMN:
                    _ 3_
     CARD: 225
     INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
     VARIABLE: IPROPF
     FORMAT:
     COLUMN:
   CARD: 224
  VARIABLE: FEED (6)
CARD: 223
INSTRUCTION: IF NUMCMG < 6, OR IDOF (6) = 0, OR IDOF (6) = 1,
                  IGNORE THE NEXT 2 CARDS.
VARIABLE: FEE (6)
FORMAT:
COLUMN:
             2 3 4 5 6 7 8 9 10 11 12
```

DUE TO MODIFICATIONS, THE NEXT DATA CARD HAS THE NUMBER 242.

CARD: 232
VARIABLES: AOJ (3)

CARD: 231
VARIABLES: AOJ (2)

CARD: 230
INSTRUCTION: IF IPROPF = 0, IGNORE THE NEXT 3 CARDS.
VARIABLES: AOJ(1)
FORMAT: ± E± ± E±
COLUMN: 234567.5310112

CGAINO (2)

```
CARD: 251
          VARIABLE: BODY11 (3,3)
         CARD: 250
        VARĮABLE: BODY11 (3,2)
        CARD: 249
        VARIABLE: BODY11 (3,1)
       CARD: 248
       VARIABLE: BODY11 (2,3)
       CARD: 247
      VARIABLE: BODY11 (2,2)
      CARD: 246
      VARIABLE: BODY11 (2,1)
     CARD: 245
     VARIABLE: BODY1I (1,3)
    CARD: 244
    VARIABLE: BODY11 (1.2)
CARD: 243
INSTRUCTION: THE NEXT 9 CARDS MUST ALWAYS BE PRESENT.
VARIABLE: BODYII (1,1)
FORMAT: + E+
COLUMN: 2 3 4 5 6 7 8 9 10 11 12
```

```
/ CARD: 255
       INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
       VARIABLE: IB2F
       FORMAT:
       COLUMN:
     CARD: 254
    INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT. VARIABLES: DO1(1) DO1(2) DO1
                                                               DOI(3)
                                                               <u>+</u>
    FORMAT:
                                          <u>+</u>
                    2 3 4 5 8 7 8 9 10 11 12
    COLUMN:
                                          15 16 17 18 19 20 21 22 23 24 25
                                                               28 29 30 31 32 33 34 35 36 37 38
  CARD: 253
  INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
  VARIABLE: OMEGA1
  FORMAT:
               <u>+</u>
-- 2 3 4 5 6 7 8 $ 10 11 12----
  COLUMN:
CARD: 252
INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
VARIABLE: THETAL
              <u>+</u>
FORMAT:
COLUMN:
              2 3 4 5 5 7 8 9 10 11 12
```

```
CARD: 259
INSTRUCTION: IF IB2F = 0, IGNORE THIS CARD.
VARIABLES: S SDOT
        FORMAT:
                                               15 16 17 18 19 20 21 22 23 24 25
        COLUMN:
                         2 3 4 5 8 7 8 9 10 11 12
     CARD: 258
     INSTRUCTION: IF IB2F = 0, IGNORE THIS CARD.
                                                                 S2(3)
                                            S2(2)
     VARIABLES: S2(1)
                                            ± .
     FORMAT:
     COLUMN:
                                                                  28 23 30 31 32 33 34 35 36 37 38
                     2 3 4 5 6 7 8 9 10 11 12
                                          15 16 17 18 19 20 21 22 23 24 25
   CARD: 257
  INSTRUCTION: IF IB2F = 0, IGNORE THIS CARD. VARIABLES: D12(1) D12(2) D12(3)
                                         <u>+</u> .
   FORMAT:
                   + . .
                                         15 16 17 18 13 20 21 22 23 24 25
                   2 3 4 5 6 7 8 9 10 11 12
                                                                28 29 30 31 32 33 34 35 35 37 38
   COLUMN:
CARD: 256
INSTRUCTION: IF IB2F = 0, IGNORE THIS CARD.
VARIABLE: B2MASS
FORMAT:
              ± •
                         E+
COLUMN:
               2 3 4 5 5 7 8 9 10 11 12
```

DUE TO MODIFICATIONS, THE NEXT DATA CARD HAS THE NUMBER 268.

CARD: 261
VARIABLES: A1J(2)

CARD: 260
INSTRUCTION: IF IPROPF = 0, IGNORE THE NEXT 2 CARDS.
VARIABLES: A1J(1)
FORMAT: + . E+ + . E+
GOLUMN: 2345878910111
SISUBBERRERERERE

```
CARD: 271
       INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD. VARIABLES: D13(1) D13(2) D1
                                                               D13(3)
       FORMAT: ±
       COLUMN:
                      2 3 4 5 6 7 8 9 10 11 12
                                           15 16 17 18 19 20 21 22 23 24 25
                                                               28 29 30 31 32 33 34 35 35 37 38
     CARD: 270
     INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
    VARIABLE: B3MASS
    FORMAT: ± . E±
                  2 3 4 5 6 7 8 9 10 11 12
     COLUMN:
  CARD: 269
  INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
VARIABLE: CP2
               <u>+</u> . <u>E+</u> _ 2 3 4 5 6 7 8 5 10 11 12 _
  FORMAT:
CARD: 268
INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
VARIABLE: CP1
             <u>+</u> •
                      E+
FORMAT:
COLUMN:
             2 3 4 5 6 7 8 9 10 11 17
```

```
CARD: 279
       INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
       VARIABLE: PEND4L
       FORMAT:
                     +
       COLUMN:
                     2 3 4 5 6 7 8 9 10 11 12
     CARD: 278
     INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
     VARIABLES: S4(1)
                                       S4(2)
                                                              S4(3)
                    ± .
     FORMAT:
     COLUMN:
                    2 3 4 5 8 7 8 9 10 11 12
                                        15 16 IF 18 19 20 21 22 23 24 25
                                                              28 29 30 31 32 33 34 35 36 37 38"
  CARD: 277
  INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD. VARIABLES: D14(1) D14(2) D1
                                                           D14(3)
  FORMAT:
                                      15 16 17 18 19 20 21 22 23 24 25
                                                           28 29 30 31 32 33 34 35 35 37 25
  COLUMN:
                  2 3 4 5 6 7 8 9 10 11 12
CARD: 276
INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
VARIABLE: B4MASS
FORMAT:
              ± . E±
COLUMN:
             2 3 4 5 6 7 8 9 10 H 12
```

```
CARD: 275
      INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
      VARIABLE: OMEGA3
      FORMAT:
      COLUMN:
                __ 2 3 4 5 5 7 8 9 10 11 12 ....
    CARD: 274
    INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD. VARIABLE: THETA3
    FORMAT:
    COLUMN:
               2 3 4 5 6 7 8 9 10 11 12
  CARD: 273
  INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
  VARIABLE: PEND3L
  FORMAT: + ... COLUMN: 2 3 4 5 8 7 8 9 10 11 12
CARD: 272
INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
VARIABLES: S3(1)
FORMAT: ±
S3(3)
                                              <u>+</u>
                                            28 29 30 31 32 33 14 35 38 27 38
```

```
CARD: 283
      INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
     VARIABLE: NGAIN
     FORMAT:
COLUMN:
                2 3
    CARD: 282
    INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
    VARIABLE: SP
   FORMAT: ±
              2 3 4 5 6 7 8 9 10 11 12
  CARD: 281
  INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD
  VARIABLE: OMEGA4
 FORMAT: + COLUMN: 2 3 4 5 5 7 8 8 10 H 12
CARD: 280 .
INSTRUCTION: IF IPNDLM = 0, IGNORE THIS CARD.
VARIABLE: THETA4
FORMAT: +
COLUMN: 2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 288
        INSTRUCTION: IF NGAIN < 5, IGNORE THIS CARD.
        VARIABLE: GAIN (5)
        COLUMN:
CARD: 287
      INSTRUCTION: IF NGAIN < 4, IGNORE THIS CARD.
      VARIABLE: GAIN (4)
      FORMAT:
                 <u>+ .</u>
                        E/+
      COLUMN:
                 2 3 4 5 6 7 8 8 10 11 12
    CARD: 286
    INSTRUCTION: IF NGAIN < 3, IGNORE THIS CARD.
    VARIABLE: GAIN (3)
    FORMAT:
COLUMN:
               ±.•
              - 2 3 4 5 6 7 6 9 10 11 12 ---
  CARD: 285
  INSTRUCTION: IF NGAIN < 2, IGNORE THIS CARD.
  VARIABLE: GAIN (2)
             23456789101112
 FORMAT:
  COLUMN:
CARD: 284
INSTRUCTION: IF NGAIN = 0, IGNORE THIS CARD.
VARIABLE: GAIN (1)
FORMAT:
           ± . E±
COLUMN:
           2 3 4 5 5 7 8 9 10 11 12
```

```
CARD: 293
         INSTRUCTION: IF NGAIN < 10, IGNORE THIS CARD.
        VARIABLE: GAIN (10)
        FORMAT: + . E+.

GOLUMN: 2 3 4 5 6 7 8 9 10 11 12
       CARD: 292
      INSTRUCTION: IF NGAIN < 9, IGNORE THIS CARD. VARIABLE: GAIN (9)
      FORMAT: + E+
COLUMN: 23455789101112
    CARD: 291
    INSTRUCTION: IF NGAIN < 8, IGNORE THIS CARD.
    VARIABLE: GAIN (8)
    FORMAT: + . E+ .
COLUMN: 23456789101112
  CARD: 290
  INSTRUCTION: IF NGAIN < 7, IGNORE THIS CARD.
  VARIABLE: GAIN (7)
  FORMAT: ± E+
COLUMN: 234587881
             _ 2 3 4 5 8 7 8 9 10 11 12 ___
CARD: 289
INSTRUCTION: IF NGAIN < 6, IGNORE THIS CARD.
VARIABLE: GAIN (6)
FORMAT: \pm . E\pm
COLUMN:
           2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 297
      INSTRUCTION: IF IDOCK = 0, IGNORE THIS CARD. VARIABLE: BDMASS
      FORMAT: + E+ COLUMN: 23456789101112
    CARD: 296
    INSTRUCTION: IF IDOCK = 0, IGNORE THIS CARD.
    FORMAT:
               + .
    COLUMN:
               2 3 4 5 8 7 8 9 10 11 12
 CARD: 295
  INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
 VARIABLE: IDOCK
 FORMAT:
  COLUMN:
CARD: 294
INSTRUCTION: THIS CARD MUST ALWAYS BE PRESENT.
VARIABLE: IGRAVF
FORMAT:
COLUMN: 3:
```

```
CARD: 306
           VARIABLE: BODYDI (3,3)
          CARD: 305
          VARIABLE: BODYDI (3,2)
         CARD: 304
         VARIABLE: BODYDI (3,1)
        CARD: 303
        VARIABLE: BODYDI (2,3)
        CARD: 302
       VARIABLE: BODYDI (2,2)
       CARD: 301
      VARIABLE: BODYDI (2,1)
      CARD: 300
     VARIABLE: BODYDI (1.3)
     CARD: 299
     VARIABLE: BODYDI (1,2)
CARD: 298
INSTRUCTION: IF IDOCK = 0, IGNORE THE NEXT 9 CARDS.
VARIABLE: BODYDI (1,1)
FORMAT:
          <u>+</u> . E+
COLUMN:
          2 3 4 5 6 7 8 9 10 11 12
```

```
CARD: 308
  INSTRUCTION: IF IDOCK = 0, IGNORE THIS CARD.
VARIABLES: DD01(1) DD01(2) DD01(3)
                     23456789101112
                                                                      <u>+</u>
   FORMAT:
   COLUMN:
                                              15 16 17 18 19 20 21 22 23 24 25
                                                                      28 29 30 31 32 33 34 35 35 37 38
CARD: 307
INSTRUCTION: IF IDOCK = 0, IGNORE THIS CARD.
                                           DTI(2)
                                                                   DTI(3)
VARIABLES: DTI(1)
                                                                  <u>+</u>
                  <u>+</u>
FORMAT:
COLUMN:
                                          15 16 17 18 19 20 2<u>1 22 2</u>3 24 25.
                 2 3 4 5 6 7 8 9 10 11 12
                                                                 28 29 30 31 32 33 34 35 36 37 38
```

# APPENDIX A, DEFINITIONS AND REFERENCES FOR INPUT VARIABLES

This appendix is in two parts. The first part contains a list of all input variables in alphabetical order. The second part contains the input variables in categories and the input variables in each category are alphabetized.

# AII(J,M,N):

$$[AII(J,M,N)] = [II_{J}] = \begin{bmatrix} AII(J,1,1) & AII(J,1,2) & AII(J,1,3) \\ AII(J,2,1) & AII(J,2,2) & AII(J,2,3) \\ AII(J,3,1) & AII(J,3,2) & AII(J,3,3) \end{bmatrix}$$

This array is the inertia matrix for the inner gimbal of the Jth control moment gyro aboard the stator. A maximum of six CMGs may be used. (i.e. J=1,6) All CMGs are also constrained to be located at the center of mass on the stator, body 0. If the Jth CMG has one or two degrees of freedom, it will have an inner gimbal. (Refer to the write up on CMGs for further discussion.)

UNITS: (slug-ft<sup>2</sup>)

FORMAT: #5006 = (1x, F11.5)

#### AIO(J,M,N):

$$\left[ \text{AIO(J,M,N)} \right] = \left[ \text{IO}_{\text{J}} \right] = \begin{bmatrix} \text{AIO(J,1,1)} & \text{AIO(J,1,2)} & \text{AIO(J,1,3)} \\ \text{AIO(J,2,1)} & \text{AIO(J,2,2)} & \text{AIO(J,2,3)} \\ \text{AIO(J,3,1)} & \text{AIO(J,3,2)} & \text{AIO(J,3,3)} \end{bmatrix}$$

This array is the inertia matrix for the outer gimbal of the Jth control moment gyro aboard the stator. A maximum of six CMGs may be used. (i.e. J=1,6) All CMGs are constrained to be located at the center of mass on the stator, body 0. The

Jth CMG will have an outer gimbsl only if it has two degrees of freedom. (Refer to the write up on CMGs for further discussion.)

UNITS: (slug-ft<sup>2</sup>)

FORMAT: #5006 = (1X, F11.5)

### ALT:

ALT is altitude of the center of mass of the space station configuration measured from the surface of the earth. All orbits are constrained to be circular with no oblateness effects. Therefore, altitude is the only pertinent orbit parameter.

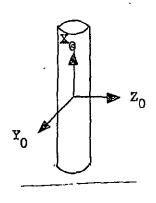
UNITS: (miles)

FORMAT: # 5004 = (1X, E11.4)

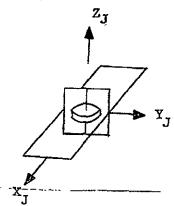
### AOCJ(J,M,N):

$$[AOCJ(J,M,N)] = [O,C_J] = \begin{bmatrix} AOCJ(J,1,1) & AOCJ(J,1,2) & AOCJ(J,1,3) \\ AOCJ(J,2,1) & AOCJ(J,2,2) & AOCJ(J,2,3) \\ AOCJ(J,3,1) & AOCJ(J,3,2) & AOCJ(J,3,3) \end{bmatrix}$$

This array is the coordinate transformation matrix from the CMG null gimbal coordinate frame to the coordinate frame of body 0, the stator. (Refer to the coordinate transformation appendix.) For example, consider the two coordinate systems shown below:



Body O Frame



Jth Null Gimbal Frame

For the above situation:

$$[AOCJ(J,M,N)] = \begin{bmatrix} 0. & 0. & 1. \\ 1. & 0. & 0. \\ 0. & 1. & 0. \end{bmatrix}$$

UNITS: (None)

FORMAT: # 5006 = (1X, F11.5)

### AOJ (M):

AOJ(1) is the distance between the jets of the pure couple producing the torque around the X axis of body 0.

AOJ(2) is the distance between the jets of the pure couple producing the torque around the Y axis of body 0.

AOJ(3) is the distance between the jets of the pure couple producing the torque around the Z axis of body 0.

Note: The variables CGAINO(1), CGAINO(2), and CGAINO(3) are also read on the same data cards as AOJ(1), AOJ(2), and AOJ(3). Funch the values of AOJ(1), AOJ(2), and AOJ(3) in columns 2 through 12 of the data cards. Non-zero values should be read in for AOJ(M). Control on an axis can be disabled by reading zero for the CGAINO.

UNITS: (feet)

FORMAT: # 5008 = (1X, E11.4,  $2\ddot{x}$ , E11.4)

### Alj(M):

AlJ(1) is the distance between the jets of the pure couple producing the torque around the X axis of body 1.

AlJ(2) is the distance between the jets of the pure couple producing the torque around the Y axis of body 1.

Note: The variables CGAIN1(1) and CGAIN1(2) are also read on the same data cards as AlJ(1) and AlJ(2).

Punch the values of AlJ(1) and AlJ(2) in columns 2 through 12 of the data cards. Non-zero values should

be read in for AlJ(M). Control on an axis can be disabled by reading zero for the CGAIN1.

UNITS: (feet)

FORMAT: # 5008 = (1X, E11.4, 2X, E11.4)

#### BDMASS:

BDMASS is the sum of the mass of body 0, the stator, and the mass of the docking vehicle. The docking vehicle is constrained to dock on body 0, the stator. BDMASS =  $m_D$ 

UNITS: (slugs)

FORMAT: #5004 = (1X, E11.4)

## BODYDI (M, N):

$$\begin{bmatrix} \text{BODYDI}(M,N) \end{bmatrix} = \begin{bmatrix} I_D \end{bmatrix} = \begin{bmatrix} \text{BODYDI}(1,1) & \text{BODYDI}(1,2) & \text{BODYDI}(1,3) \\ \text{BODYDI}(2,1) & \text{BODYDI}(2,2) & \text{BODYDI}(2,3) \\ \text{BODYDI}(3,1) & \text{BODYDI}(3,2) & \text{BODYDI}(3,3) \end{bmatrix}$$

This array is the inertia matrix of the docked body which consists of the docking vehicle connected to the stator.

UNITS: (slug-ft<sup>2</sup>)

FORMAT: #5004 = (1X, E11.4)

#### BODYOI (M,N):

$$\begin{bmatrix} \text{BoDYOI}(M,N) \end{bmatrix} = \begin{bmatrix} I_0 \end{bmatrix} = \begin{bmatrix} \text{BoDYOI}(1,1) & \text{BoDYOI}(1,2) & \text{BoDYOI}(1,3) \\ \text{BoDYOI}(2,1) & \text{BoDYOI}(2,2) & \text{BoDYOI}(2,3) \\ \text{BoDYOI}(3,1) & \text{BoDYOI}(3,2) & \text{BoDYOI}(3,3) \end{bmatrix}$$

This array is the inertia matrix of body 0, the stator.

FORMAT: #5004 = (1X, E11.4)

### BODY11 (M, N):

$$\begin{bmatrix} \text{BODYII}(M,N) \end{bmatrix} = \begin{bmatrix} I_1 \end{bmatrix} = \begin{bmatrix} \text{BODYII}(1,1) & \text{BODYII}(1,2) & \text{BODYII}(1,3) \\ \text{BODYII}(2,1) & \text{BODYII}(2,2) & \text{BODYII}(2,3) \\ \text{BODYII}(3,1) & \text{BODYII}(3,2) & \text{BODYII}(3,3) \end{bmatrix}$$

This array is the inertia matrix for body 1, the rotor.

UNITS: (slug-ft<sup>2</sup>)

FORMAT: #5004 = (1X, E11.4)

#### BOMASS:

BOMASS is the mass of body 0, the stator. BOMASS =  $m_0$ 

UNITS: (slugs)

FORMAT: # 5004 = (1X, E11.4)

### BIMASS:

BlMASS is the mass of body 1, the rotor. BLMASS =  $m_1$ 

UNITS: (slugs)

FORMAT: # 5004 = (1X, E11.4)

#### B2MASS:

B2MASS is the mass of body 2, the elevator. B2MASS =  $m_2$ UNITS: (slugs)

FORMAT: #5004 = (1X, E11.4)

#### B3MASS:

B3MASS is the mass of body 3, a pendulum. B3MASS =  $m_3$ 

UNITS: (slugs)

FORMAT: # 5004 = (1X, E11.4)

### B4MASS:

B4)(ASS is the mass of body 4, a pendulum. B4MASS =  $m_L$ 

UNITS: (slugs)

FORMAT: #5004 = (1X, E11.4)

#### CA(M):

CA(1), CA(2), and CA(3) are the three direction cosines of the desired attitude reference direction in the inertial frame.

UNITS: (None)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

#### CGAINO(M):

CGAINO(1) equals the control gain of all four reaction jets in the pure force couples producing torque around the X axis of body 0.

CGAINO(2) equals the control gain of all four reaction jets in the pure force couples producing torque around the Y axis of body 0.

CGAINO(3) equals the control gain of all four reaction jets in the pure force couples producing torque around the Z axis of body 0.

Note: The variables AOJ(1), AOJ(2), and AOJ(3) are also read in on the same data cards as CGAINO(1), CGAINO(2), and CGAINO(3). Punch the values of CGAINO(1), CGAINO(2), and CGAINO(3) in columns 15 through 25 of the data cards.

UNITS: (1b/radians/second)

FORMAT: #5008 = (1X, E11.4, 2X, E11.4)

### CGAIN1(M):

CGAIN1(1) equals the control gain of all four reaction jets in the pure force couples producing torque around the X axis of body 1.

CGAIN1(2) equals the control gain of all four reaction jets in the pure force couples producing torque around the Y axis of body 1.

Note: The variables AlJ(1) and AlJ(2) are also read in on the same date cards as CGAIN1(1) and CGAIN1(2). Punch the values of CGAIN1(1) and CGAIN1(2) in columns 15 through 25 of the data cards.

UNITS: (1b/radians/second)

FORMAT: #5008 = (1X, E11.4, 2X, E11.4)

#### CP1 and CP2:

CPl and CP2 are parameters used in determining the stiffness and the resonant frequency of the pendulums. For example, the control laws which are governed by the parameters are:

T13 = - CP1 \* OMEGA3 - CP2 \* THETA3

 $T14 = - CP1 * OMEGA4 - CP2 * (THETA4 - \pi)$ 

Note: These variables are read on separate data cards.

UNITS: (none)

FORMAT: #5004 = (1X, E11.4)

### DD01(M):

DD01(1), DD01(2), and DD01(3) are the X, Y, and Z components of the vector from the center of mass of the docked body to the hinge line of body 1, the rotor. The vector is expressed in body 0 coordinates. The docked body shall be defined as the configuration of the docking vehicle attached to body 0.

UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

### DELTAT:

 $DELTAT = \Delta t$ 

DELTAT is the time increment used in the integration algorithm which solves the rotational equations of motion. When "TIME" is updated we have:

TIME = TIME + DELTAT

Note: Punch the value of DELTAT in columns 28 through 38

UNITS: (seconds)

FORMAT: # 5002 = (1X, 3(F11.5, 2X))

#### D01(M):

D01(1), D01(2), and D01(3) are the X, Y, and Z components of the vector from the center of mass of body 0 to the hinge line of body 1, the rotor. The vector is expressed in body 0 coordinates. D01(1) should in most cases be zero.

UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

### DTI (M):

DTI(1), DTI(2) and DTI(3) are the X, Y, and Z components of the docking torque impulse.

UNITS: 1b-ft-sec

FORMAT: #5002 = (1X, 3(F11.5, 2X))

#### DTIME:

DTIME is the time when docking occurs. (i.e. "Docking Time") The restrictions placed on DTIME are as follows:

- a) T<sub>start</sub> < DTIME < T<sub>stop</sub>
- b) DTIME must be an integer multiple of  $\Delta t$ .

UNITS: (seconds)

FORMAT: #5006 = (1X, F11.5)

### D12(M):

D12(1), D12(2) and D12(3) are the X, Y and Z components of a fixed vector locating the starting position of the movable mass, the elevator. The vector equation that describes the motion of the movable mass is  $l_2 = \bar{d}_{12} + \bar{s}_2 s$ . Where  $\bar{s}_2$  is a unit vector which defines the direction in which the movable mass travels and s is a scalar prespecified function of time. For most cases s(t=0)=0 so that  $\bar{d}_{12}$  specifies the initial starting position of the movable mass. The elevator is known alternately as the movable mass or body 2. D12 is expressed in body I coordinates. For example, if the elevator were constrained to travel along the X axis, then  $\bar{d}_{12}$  could have the following values: D12(1) = 1., D12(2) = 0., D12(3) = 0.

UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

#### D13(M):

D13(1), D13(2), and D13(3) are the X, Y, and Z components of the vector from the center of mass of body 1 to the hinge line of body 3. D13 is expressed in body 1 coordinates.

UNITS: (feet)

FORMAT: # 5002 = (1X, 3(F11.5, 2X))

# D14(M):

D14(1), D14(2), and D14(3) are the X, Y, and Z components of the vector from the center of mass of body 1 to the hinge line of body 4.

D14 is expressed in body 1 coordinates.

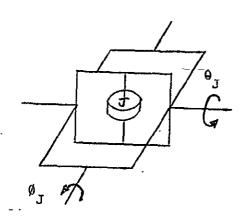
UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

### FEE(J):

 $FEE(J) = \emptyset_{J}$ 

FEE(J) is the outer gimbal angle of a two degree of freedom control moment gyro as shown pictorially below:



The subscript J refers to the number assigned to the CMG. (Refer to the write up on CMGs for further discussion.)

UNITS: (radians)

- FORMAT: # 5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

## FEED(J):

 $FEED(J) = \emptyset_{J}$ 

FEED(J) is the outer gimbal rate of a two degree of freedom control moment gyro. The subscript J refers to the number assigned to the CMG. (Refer to the write up on CMGs for further discussion.)

UNITS: (radians/second)

FORMAT: #5006 = (1X, F11.5)

### GAIN(M):

GAIN(M) is an array of numbers the dimension of which is determined by another input variable NGAIN. These numbers, once read in, are stored in common and can be used for a variety of purposes. In many CMG control laws it is necessary to have control gains. GAIN(M) can be used for this purpose among others.

UNITS: (None)

FORMAT: # 5004 = (1X, E11.4)

### HW(J):

HW(J) is the angular momentum of the wheel associated with the Jth momentum device. (Refer to the write up on CMGs for further discussion.)

UNITS: (slug-ft<sup>2</sup>/second)

FORMAT: #5004 = (1X, E11.4)

#### IATTIF:

IATTIF is the attitude flag.

IATTIF = 1 implies an attempt to change attitude will be made.

IATUTE = 0 implies an attempt to change attitude will not be made.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, I2)

### IB2F:

IB2F is the body 2 flag. (i.e. the elevator flag)

IB2F = 1 implies body 2 will be present.

IB2F = 0 implies body 2 will not be present.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, I2)

### IDOCK:

IDOCK is the docking flag.

IDOCK = 1 implies docking will occur.

IDOCK = 0 implies docking will not occur.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

.UNITS: (none)

FORMAT: #5000 = (1X, 12)

### IDOF(J):

- IDOW(J) = 1 implies the Jth controller aboard body 0 is a one degree of freedom control moment gyro.
- IDOF(J) = 2 implies the Jth controller aboard body 0 is a two degree of freedom control moment gyro.

SPECIAL INSTRUCTIONS: Punch a 0, 1, or a 2 in column 3 of the data card.

UND TS: (none)

FORMAT: #5000 = (1X, 12)

### IGRAVF:

IGRAVF is the gravity gradient flag.

IGRAVF = 1 implies gravity gradient torques will be present.

IGRAVF = 0 implies gravity gradient torques will not be present.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: # 5000 = (1X, 12)

#### IPNDLM:

IPNDLM is the pendulum flag.

IPNDLM = 1 implies body 3 and body 4, the pendulums, will be present.

IPNDLM = 0 implies body 3 and body 4, the pendulums, will not be present.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

### IPRINT:

IPRINT is an integer variable used to determine how often output data is printed. Data is printed in time increments of IPRINT \* DELTAT. For example, if IPRINT = 50 and DELTAT = .2, then data will be printed when time = 10, 20, 30, 40, 50, . . .

SPECIAL INSTRUCTIONS: If IPRINT has a value less than 10, punch the integer in column 3 of the data card. If IPRINT has a value greater than 9, punch the integer in columns 2 and 3.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

### IPROPF:

IPROPF is the propulsion flag.

IPROPF = 1 implies propulsion forces will be considered.

IPROPF = 0 implies propulsion forces will not be considered.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

### NDECK:

NDECK is an integer variable equal to the number of data decks present at run time.

SPECIAL INSTRUCTIONS: This variable goes in front of the first data deck only. If NDECK has a value less than 10, punch the integer in column 3 of the data card. If NDECK has a value greater than 9, punch the integer in columns 2 and 3.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

### NGAIN:

NGAIN is an integer variable and refers to the number of arbitrary gains which are input. If NGAIN = 3 then values for GAIN(1), GAIN(2) and GAIN(3) will be input. The maximum value of NGAIN is 10.

SPECIAL INSTRUCTIONS: If NGAIN has a value less than \*10, punch the integer in column 3 of the data card. Otherwise, use columns 2 and 3.

UNITS: (none)

FORMAT: #5000 = (1X, I2)

### NUMCMG:

NUMCMG is the number of controllers aboard body 0. A maximum of 6 controllers may be used.

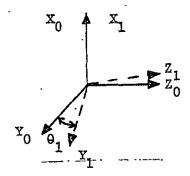
SPECIAL INSTRUCTIONS: Punch the integer in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

### OMEGA1:

OMEGAl is the initial relative angular velocity measure about the spin axis between bodies 0 and 1. Another definition of OMEGAl can be visualized by referring to the sketch shown below showing the orthogonal coordinate systems located on bodies 0 and 1.



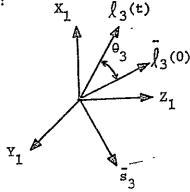
Implicit in this sketch is the hinge line between the stator and roto: is aligned parallel to both the  $\overline{X}_0$  and  $\overline{X}_1$  axes. Therefore, the orientation of the stator and the rotor differ only in a rotation  $\theta_1$  = THETAl and OMEGAl =  $\theta_1$ .

UNITS: (radians per second)

FORMAT: #5006 = (1X, F11.5)

### OMEGA3:

OMEGA3 is the angular velocity of body 3 about the hinge line  $s_3$ . OMEGA3 is also the time derivative of THETA3 when the datum for the angle THETA3 will be the  $\overline{Y}_1$ ,  $\overline{Z}_1$  plane as illustrated below:



In other words,  $\bar{s}_3$  determines the positive direction of rotation by the right hand rule and the positive  $Y_1$  -  $Z_1$  plane determines to starting position.

UNITS: (radians per second)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

### OMEGA4:

OMEGA4 is the angular velocity of body 4 about the hinge line  $\vec{s}_4$ . OMEGA4 is also the time derivative of TFETA4 where the datum for the angle THETA4 is the same as THETA3. (See OMEGA3)

UNITS: (radians per second)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

### PEND3L:

PEND3L is the scalar distance from the hinge line,  $\bar{s}_3$ , to the center of mass of body 3. (i.e. the length of pendulum 3)

UNITS: (feet)

FORMAT: #5006 = (1X, F11.5)

### PEND4L:

PEND4L is the scalar distance from the hinge line,  $\bar{s}_4$ , to the center of mass of body 4. (i.e. the length of pendulum 4)

UNITS: (feet)

FORMAT: #5006 = (1X, F11.5)

S:

S is a scalar parameter used in defining the position of body 2. S defines the magnitude of displacement of body 2 from the zero position.

Note: Punch the value of S in columns 2 through 12.

UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

INITIAL VALUE AT TIME = T

### SDOT:

SDOT defines the magnitude of the velocity vector of body 2.

Note: Punch the value of SDOT in columns 15 through 25.

UNITS: (feet per second)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

INITIAL VALUE AT TIME = T

### SP:

SP is the desired spin magnitude of body 1 relative to body 0.

UNITS: (radians per second)

FORMAT: #5006 = (1X, F11.5)

# S2(M):

S2(1), S2(2), and S2(3) are the X, Y, and Z components of a unit vector defining the direction of travel of body 2. s2 is expressed in body 1 coordinates.

UNITS: (none)

-FORMAT: #5002 = (1X, 3(F11.5, 2X))

### 83(M):

S3(1), S3(2), and S3(3) are the X, Y, and Z components of a unit vector which defines the hinge line of body 3.  $s_3$  is expressed in body I coordinates. S3(1) must always be zero.

UNITS: (none)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

### S4(M):

S4(1), S4(2), and S4(3) are the X, Y, and Z components of a unit vector which defines the hinge line of body 4.  $s_4$  is expressed in body 1 coordinates. S4(1) must always be zero.

UNITS: (none)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

# THATA(J):

THAT(J) is the gimbal angle of the Jth controller aboard body 0 assuming this controller is either a one or two degree of freedom control moment gyro. If it is a two degree of freedom CMG, then this variable refers to the inner gimbal angle. J may have a maximum value of 6.

UNITS: (radians)

FORMAT: # 5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

# THATAD(J):

THATAD(J) is the gimbal rate associated with THATA(J).

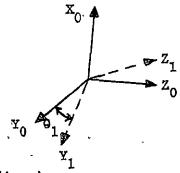
UNITS: (radians per second)

FORMAT: #5006 = (1x, F11.5)

INITIAL VALUE AT TIME = T

### THETAL:

THETAl is the relative angular displacement measured about the spin axis, between bodies 0 and 1.



UNITS: (radians)

FORMAT: # 5006= (1X, F11.5)

INITIAL VALUE AT TIME = T

### : CATEDIT

THETA3 is the angle between pendulum 3 and the Y, Z, plane. The axis about which THETA3 rotates is the hinge line s<sub>3</sub>. For an explanation of the THETA3 datum refer to the discussion of OMEGA3.

UNITS: (radians)

FORMAT: # 5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T start

# THETA4:

THETA4 is the angle between pendulum 4 and the Y, Z, plane. The axis about which THETA4 rotates is the hinge line s<sub>4</sub>. The datum for THETA4 is the same as for THETA3.

UNITS: (radians)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

# TIBOI (M, N):

$$[TIBOI(M,N)] = \begin{bmatrix} TIBOI(1,1) & TIBOI(1,2) & TIBOI(1,3) \\ TIBOI(2,1) & TIBOI(2,2) & TIBOI(2,3) \\ TIBOI(3,1) & TIBOI(3,2) & TIBOI(3,3) \end{bmatrix}$$

This array is the initial transformation matrix of the body 0 coordinate system to the inertial coordinate system. If initially body 0 is aligned with the inertial system, TIBOI(M,N) would be the identity matrix. Refer to the coordinate transformation appendix for further details.

UNITS: (none)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUES AT TIME = T

#### TSTART:

TSTART is the time at which you wish the program to start calculating the equations of motion. Except for restarting, TSTART is usually set to zero.

SPECIAL INSTRUCTIONS: Punch the value of TST RT in columns 2 through 12.

UNITS: (seconds)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

# TSTOP:

TSTOP is the time at which you wish the program to stop calculating.

SPECIAL INSTRUCTIONS: Punch the value of TSTOP in columns 15 through 25.

UNITS: (seconds)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

# WO(M):

WO(1), WO(2), and WO(3) are the X, Y, and Z components of the angular velocity vector of body 0.

UNITS: (radians per second)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

INITIAL VALUES AT TIME = T

#### GENERAL INPUT VARIABLES

### ALT:

ALT is altitude of the center of mass of the space station configuration measured from the surface of the earth. All orbits are constrained to be circular with no oblateness effects. Therefore, altitude is the only pertinent orbit parameter.

UNITS: (miles)

FORMAT: # 5004 = (1X, E11.4)

### BDMASS:

BDMASS is the sum of the mass of body 0, the stator, and the mass of the docking vehicle. The docking vehicle is constrained to dock on body 0, the stator. BDMASS =  $m_p$ 

UNITS: (slugs)

FORMAT: # 5004 = (1X, E11.4)

### BODYDI (M, N):

$$\begin{bmatrix} \text{BODYDI}(1,1) & \text{BODYDI}(1,2) & \text{BODYDI}(1,3) \\ \text{BODYDI}(2,1) & \text{BODYDI}(2,2) & \text{BODYDI}(2,3) \\ \text{BODYDI}(3,1) & \text{BODYDI}(3,2) & \text{BODYDI}(3,3) \end{bmatrix}$$

This array is the inertia matrix of the docked body which consists of the docking vehicle connected to the stator.

UNITS: (slug-ft<sup>2</sup>)

FORMAT: # 5004 = (1x, E11.4)

# CA(M):

CA(1), CA(2), and CA(3) are the three direction cosines of the desired attitude reference direction in the inertial frame.

UNITS: (None)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

# CP1 and CP2:

CPl and CP2 are parameters used in determining the stiffness and the resonant frequency of the pendulums. For example, the control laws which are governed by the parameters are:

T13 = - CP1 \* OMEGA3 - CP2 \* THETA3

 $T14 = - CP1 * OMEGA4 - CP2 * (THETA4 - \pi)$ 

Note: These variables are read on separate data cards.

UNITS: (none)

FORMAT: #5004 = (1X, E11.4)

### DD01(M):

DD01(1), DD01(2), and DD01(3) are the X, Y, and Z components of the vector from the center of mass of the docked body to the hinge line of body 1, the rotor. The vector is expressed in body 0 coordinates. The docked body shall be defined as the configuration of the docking vehicle attached to body 0.

UNITS: (feet)

FORMAT: # 5002 = (1X, 3(F11.5, 2X))

# DELTAT:

 $DELTAT = \Delta t$ 

DELTAT is the time increment used in the integration algorithm which solves the rotational equations of motion. When "TIME" is updated we have:

TIME - TIME + DELTAT

Note: Punch the value of DELTAT in columns 28 through 38.

UNITS: (seconds)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

### DTI(M):

DTI(1), DTI(2) and DTI(3) are the X, Y, and Z components of the docking torque impulse.

UNITS: 1b-ft-sec

FORMAT: #5002 = (1X, 3(F11.5, 2X))

### DTIME:

DTIME is the time when docking occurs. (i.e. "Docking Time"). The restrictions placed on DTIME are as follows:

- a) T<sub>start</sub> < DTIME < T<sub>stop</sub>
- b) DTIME must be an integer multiple of  $\Delta t$ .

UNITS: (seconds) .

FORMAT: #5006 = (1X, F11.5)

# GAIN(M):

GAIN(M) is an array of numbers the dimension of which is determined by another input variable NGAIN. These numbers, once read in, are stored in common and can be used for a variety of purposes. In many CMG control laws it is necessary to have control gains. GAIN(M) can be used for this purpose among others.

UNITS: (None)

FORMAT: #5004 = (1X, E11.4)

## IATTIF:

IATTIF is the attitude flag.

IATTIF = 0 implies an attempt to change attitude will not be made.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: # 5000 = (1X, I2)

### IB2F:

IB2F is the body 2 flag. (i.e. the elevator flag)

IB2F = 1 implies body 2 will be present.

IB2F = 0 implies body 2 will not be present.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, I2)

### IDOCK:

IDOCK is the docking flag.

IDOCK = 1 implies docking will occur.

IDOCK = 0 implies docking will not occur.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

### **IGRAVF:**

IGRAVF is the gravity gradient flag.

IGRAVF = 1 implies gravity gradient torques will be present.

IGRAVF = 0 implies gravity gradient torques will not be present.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

# IPNDLM:

IPNDLM is the pendulum flag.

IPNDLM = 1 implies body 3 and body 4, the pendulums, will be present.

IPNDLM = 0 implies body 3 and body 4, the pendulums, will not be present.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

#### IPRINT:

IPRINT is an integer variable used to determine how often output data is printed. Data is printed in time increments of IPRINT \* DELTAT. For example, if IPRINT = 50 and DELTAT = .2, then data will be printed when time = 10, 20, 30, 40, 50, . . .

SPECIAL INSTRUCTIONS: If IPRINT has a value less than 10, punch the integer in column 3 of the data card. If IPRINT has a value greater than 9, punch the integer in columns 2 and 3.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

# IPROPF:

IPROPF is the propulsion flag.

IPROPF = 1 implies propulsion forces will be considered.

IPROPF = 0 implies propulsion forces will not be considered.

SPECIAL INSTRUCTIONS: Punch a 0 or a 1 in column 3 of the data card. . .

UNITS: (none)

FORMAT: #5000 = (1X, 12)

# NDECK:

NDECK is an integer variable equal to the number of data decks present at run time.

SPECIAL INSTRUCTIONS: This variable goes in front of the first data deck only. If NDECK has a value less than 10, punch the integer in column 3 of the data card. If NDECK has a value greater than 9, punch the integer in columns 2 and 3.

UNITS: (none)

FORMAT: #5000 = (1x, 12)

# NGAIN:

NGAIN is an integer variable and refers to the number of arbitrary gains which are input. If NGAIN = 3 then values for GAIN(1), GAIN(2) and GAIN(3) will be input. The maximum value of NGAIN is 10.

SPECIAL INSTRUCTIONS: If NGAIN has a value less than 10, punch the integer in column 3 of the data card. Otherwise, use columns 2 and 3.

UNITS: (none)

FORMAT: #5000 = (1X, I2)

### TSTART:

TSTART is the time at which you wish the program to start calculating the equations of motion. Except for restarting, TSTART is usually set to zero.

SPECIAL INSTRUCTIONS: Punch the value of TSTART in columns 2 through 12.

UNITS: (seconds)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

# TSTOP:

TSTOP is the time at which you wish the program to stop calculating.

SPECIAL INSTRUCTIONS: Punch the value of TSTOP in columns 15 through 25.

UNITS: (seconds)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

#### · BODY 0 INPUT VARIABLES

# [AII(J,M,N)]:

$$[AII(J,M,N)] = [II_{J}] = \begin{bmatrix} AII(J,1,1) & AII(J,1,2) & AII(J,1,3) \\ AII(J,2,1) & AII(J,2,2) & AII(J,2,3) \\ AII(J,3,1) & AII(J,3,2) & AII(J,3,3) \end{bmatrix}$$

This array is the inertia matrix for the inner gimbal of the Jth control moment gyro aboard the stator. A maximum of six CMGs may be used. (i.e. J=1,6) All CMGs are also constrained to be located at the center of mass on the stator, body 0. If the Jth CMG has one or two degrees of freedom, it will have an inner gimbal. (Refer to the write up on CMGs for further discussion.)

UNITS: (slug-ft<sup>2</sup>).

FORMAT: #5006 = (1X, F11.5)

# AIO(J,M,N):

$$[AIO(J,M,N)] = [IO_J] = \begin{bmatrix} AIO(J,1,1) & AIO(J,1,2) & AIO(J,1,3) \\ AIO(J,2,1) & AIO(J,2,2) & AIO(J,2,3) \\ AIO(J,3,1) & AIO(J,3,2) & AIO(J,3,3) \end{bmatrix}$$

This array is the inertia matrix for the outer gimbal of the Jth control moment gyro aboard the stator. A maximum of six CMGs may be used. (i.e. J=1,6) All CMGs are constrained to be located at the center of mass on the stator, body 0. The Jth CMG will have an outer gimbal only if it has two degrees of freedom. (Refer to the write up on CMGs for further discussion.)

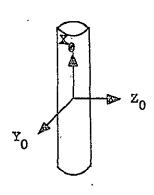
UNITS: (slug-ft<sup>2</sup>)

FORMAT: # 5006 = (1x, F11.5)

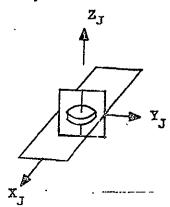
# AOCJ (J,M,N):

$$[AOCJ(J,M,N)] = [O,C_{J}] = \begin{bmatrix} AOCJ(J,1,1) & AOCJ(J,1,2) & AOCJ(J,1,3) \\ AOCJ(J,2,1) & AOCJ(J,2,2) & AOCJ(J,2,3) \\ AOCJ(J,3,1) & AOCJ(J,3,2) & AOCJ(J,3,3) \end{bmatrix}$$

This array is the coordinate transformation matrix from the CMG null gimbal coordinate frame to the coordinate frame of body 0, the stator. (Refer to the coordinate transformation appendix.) For example, consider the two coordinate systems shown below:



Body 0 Frame



Jth Null Gimbal Frame

For the above situation:

$$[AOCJ(J,M,N)] = \begin{bmatrix} 0. & 0. & 1. \\ 1. & 0. & 0. \\ 0. & 1. & 0. \end{bmatrix}$$

UNITS: (None)

FORMAT: # 5006 = (1X, F11.5)

### AOJ(M):

AOJ(1) is the distance between the jets of the pure couple producing the torque around the X axis of body 0.

AOJ(2) is the distance between the jets of the pure couple producing the torque around the Y axis of body 0.

AOJ(3) is the distance between the jets of the pure couple producing the torque around the Z axis of body 0.

Note: The variables CGAINO(1), CGAINO(2), and CGAINO(3) are also read on the same data cards as AOJ(1), AOJ(2), and AOJ(3). Punch the values of AOJ(1), AOJ(2), and AOJ(3) in columns 2 through 12 of the data cards.

UNITS: (feet)

FORMAT: # 5008 = (1x, E11.4, 2x, E11.4)

# BODYOI (M,N):

$$\begin{bmatrix} \text{BoDYOI}(M,N) \end{bmatrix} = \begin{bmatrix} I_0 \end{bmatrix} = \begin{bmatrix} \text{BoDYOI}(1,1) & \text{BoDYOI}(1,2) & \text{BoDYOI}(1,3) \\ \text{BoDYOI}(2,1) & \text{BoDYOI}(2,2) & \text{BoDYOI}(2,3) \\ \text{BoDYOI}(3,1) & \text{BoDYOI}(3,2) & \text{BoDYOI}(3,3) \end{bmatrix}$$

This array is the inertia matrix of body 0, the stator.

UNITS: (slug-ft<sup>2</sup>)

FORMAT: # 5004 = (1X, E11.4)

### BOMASS:

BOMASS is the mass of body 0, the stator. BOMASS =  $m_0$ 

UNITS: (slugs)

FORMAT: # 5004 = (1X, E11.4)

# CGAINO(M):

CGAINO(1) equals the control gain of all four reaction jets in the pure force couples producing torque around the X axis of body 0.

GGAINO(2) equals the control gain of all four reaction jets in the pure force couples producing torque around the Y axis of body 0.

CGAINO(3) equals the control gain of all four reaction jets in the pure force couples producing torque around the Z axis of body 0.

Note: The variables AOJ(1), AOJ(2), and AOJ(3) are also read in on the same data cards as CGAINO(1), CGAINO(2), and CGAINO(3). Punch the values of CGAINO(1), CGAINO(2), and CGAINO(3) in columns 15 through 25 of the data cards.

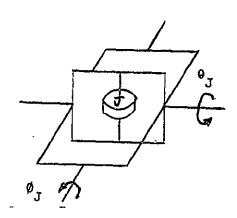
UNITS: (1b/radians/second)

FORMAT: # 5008 = (1X, E11.4, 2X, E11.4)

### FEE(J):

 $FEE(J) = \emptyset_{\tau}$ 

FEE(J) is the outer gimbal angle of a two degree of freedom control moment gyro as shown pictorially below:



The subscript J refers to the number assigned to the CMG. (Refer to the write up on CMGs for further discussion.)

UNITS: (radians)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

# FEED(J):

$$FEED(J) = \emptyset_{J}$$

FEED(J) is the outer gimbal rate of a two degree of freedom control moment gyro. The subscript J refers to the number assigned to the CMG. (Refer to the write up on CMGs for further discussion.)

UNITS: (radians/second)

FORMAT: #5006 = (1X, F11.5)

# HW(J):

HW(J) is the angular momentum of the wheel associated with the Jth momentum device. (Refer to the write up on CMGs for further discussion.)

UNITS: (slug-ft<sup>2</sup>/second)

FORMAT: # 5004 = (1X, E11.4)

# IDOF(J):

IDOF(J) = 2 implies the Jth controller aboard body 0 is a
 two degree of freedom control moment gyro.

SPECIAL INSTRUCTIONS: Punch a 0, 1, or a 2 in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, 12)

### NUMCMG:

NUMCMG is the number of controllers aboard body 0. A maximum of 6 controllers may be used.

SPECIAL INSTRUCTIONS: Punch the integer in column 3 of the data card.

UNITS: (none)

FORMAT: #5000 = (1X, I2)

# THATA(J):

THAT(J) is the gimbal angle of the Jth controller aboard body 0 assuming this controller is either a one or two degree of freedom control moment gyro. If it is a two degree of freedom CMG, then this variable refers to the inner gimbal angle. J may have a maximum value of 6.

UNITS: (radians)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T start

# THATAD(J):

THATAD(J) is the gimbal rate associated with THATA(J).

UNITS: (radians per second)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

# TIBOI (M, N):

[TIBOI(M,N)] = 
$$\begin{bmatrix} TIBOI(1,1) & TIBOI(1,2) & TIBOI(1,3) \\ TIBOI(2,1) & TIBOI(2,2) & TIBOI(2,3) \\ TIBOI(3,1) & TIBOI(3,2) & TIBOI(3,3) \end{bmatrix}$$

This array is the initial transformation matrix of the body 0 coordinate system to the inertial coordinate system. If initially body 0 is aligned with the inertial system, TIBOI(M,N) would be the identity matrix. Refer to the coordinate transformation appendix for further details.

UNITS: (none)

FORMAT: # 5006 = (1X, F11.5)

INITIAL VALUES AT TIME = T

# WO (M):

WO(1), WO(2), and WO(3) are the X, Y, and Z components of the angular velocity vector of body 0.

UNITS: (radians per second)

FORMAT: # 5002 = (1X, 3(F11.5, 2X))

INITIAL VALUES AT TIME = T

### BODY 1 INPUT VARIABLES

### Alj(M):

AlJ(1) is the distance between the jets of the pure couple producing the torque around the X axis of body 1.

AlJ(2) is the distance between the jets of the pure couple producing the torque around the Y axis of body 1.

Note: The variables CGAIN1(1) and CGAIN1(2) are also read on the same data cards as AlJ(1) and AlJ(2). Punch the values of AlJ(1) and AlJ(2) in columns 2 through 12 of the data cards.

UNITS: (feet)

FORMAT: #5008 = (1X, E11.4, 2X, E11.4)

# BODY11 (M, N):

$$[BODYII(M,N)] = [I_1] = \begin{bmatrix} BODYII(1,1) & BODYII(1,2) & BODYII(1,3) \\ BODYII(2,1) & BODYII(2,2) & BODYII(2,3) \\ BODYII(3,1) & BODYII(3,2) & BODYII(3,3) \end{bmatrix}$$

This array is the inertia matrix for body 1, the rotor.

UNITS: (slug-ft<sup>2</sup>)

FORMAT: # 5004 = (1X, E11.4)

#### B1MASS:

BIMASS is the mass of body 1, the rotor. BIMASS =  $m_{\chi}$ 

UNITS: (slugs)

FORMAT: #5004 = (1x, E11.4)

### CGAIN1 (M):

CGAINI(1) equals the control gain of all four reaction jets in the pure force couples producing torque around the X axis of body 1.

CGAIN1(2) equals the control gain of all four reaction jets in the pure force couples producing torque around the  $Y_{\rm o}$  axis of body 1.

Note: The variables AlJ(1) and AlJ(2) are also read in on the same date cards as CGAIN1(1) and CGAIN1(2). Punch the values of CGAIN1(1) and CGAIN1(2) in columns 15 through 25 of the data cards.

UNITS: (lb/radians/second)

FORMAT: # 5008 = (1X, E11.4, 2X, E11.4)

# DO1(M):

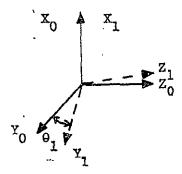
D01(1), D01(2), and D01(3) are the X, Y, and Z components of the vector from the center of mass of body 0 to the hinge line of body 1, the rotor. The vector is expressed in body 0 coordinates. D01(1) should in most cases be zero.

UNITS: (feet) &

FORMAT: #5002 = (1X, 3(F11.5, 2X))

#### OMEGA1:

OMEGAl is the initial relative angular velocity measure about the spin axis between bodies 0 and 1. Another definition of OMEGAl can be visualized by referring to the sketch shown below showing the orthogonal coordinate systems located on bodies 0 and 1.



Imp icit in this sketch is the hinge line between the stator and roto is aligned parallel to both the  $\overline{X}_0$  and  $\overline{X}_1$  axes. Therefore, the orientation of the stator and the rotor differ only in a rotation  $\theta_1$  = THETAl and OMEGAl =  $\theta_1$ .

UNI 'S: (radians per second)

FORMAT: #5006 = (1X, F11.5)

SP:

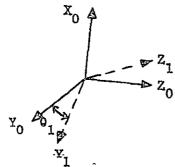
SP is the desired spin magnitude of body 1 relative to body 0.

UNITS: (radians per second)

FORMAT: # 5006 = (1X, F11.5)

# THETA1:

THETAl is the relative angular displacement measured about the spin axis, between bodies 0 and 1.



UNITS: (radians)

FORMAT: # 5006= (1X, F11.5)

INITIAL VALUE AT TIME = T

#### BODY 2 INPUT VARIABLES

### B2MASS:

B2MASS is the mass of body 2, the elevator. B2MASS =  $m_2$ 

UNITS: (slugs)

FORMAT: # 5004 = (1X, E11.4)

# D12 (M):

D12(1), D12(2) and D12(3) are the X, Y and Z components of a fixed vector locating the starting position of the movable mass, the elevator. The vector equation that describes the motion of the movable mass is  $l_2 = \bar{d}_{12} + \bar{s}_2 s$ . Where  $s_2$  is a unit vector which defines the direction in which the movable mass travels and s is a scalar prespecified function of time. For most cases s(t=0)=0 so that  $\bar{d}_{12}$  specifies the initial starting position of the movable mass. The elevator is known alternately as the movable mass or body 2. D12 is expressed in body 1 coordinates. For example, if the elevator were constrained to travel along the X axis, then  $\bar{d}_{12}$  could have the following values: D12(1) = 1., D12(2) = 0., D12(3) = 0.

UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

<u>s</u>:

S is a scalar parameter used in defining the position of body 2. S defines the magnitude of displacement of body 2 from the zero position.

Note: Punch the value of S in columns 2 through 12.

UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

INITIAL VALUE AT TIME = T

# SDOT:

SDOT defines the magnitude of the velocity vector of body 2.

Note: Punch the value of SDOT in columns 15 through 25.

UNITS: (feet per second)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

INITIAL VALUE AT TIME = T

# S2 (M):

S2(1), S2(2), and S2(3) are the X, Y, and Z components of a unit vector defining the direction of travel of body 2.  $\tilde{s}_2$  is expressed in body 1 coordinates.

UNITS: (none)

FORMAT: # 5002 = (1x, 3(F11.5, 2x))

#### BODY 3 INPUT VARIABLES

### B3MASS:

B3MASS is the mass of body 3, a pendulum. B3MASS =  $m_3$ 

UNITS: (slugs)

FORMAT: #5004 = (1X, E11.4)

# D13(M):

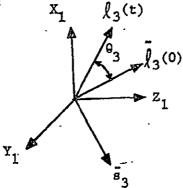
D13(1), D13(2), and D13(3) are the X, Y, and Z components of the vector from the center of mass of body 1 to the hinge line of body 3. D13 is expressed in body 1 coordinates.

UNITS: (feet)

FORMAT: # 5002 = (1x, 3(F11.5, 2x))

### OMEGA3:

OMEGA3 is the angular velocity of body 3 about the hinge line  $\bar{s}_3$ . OMEGA3 is also the time derivative of THETA3 when the datum for the angle THETA3 will be the  $\bar{Y}_1$ ,  $\bar{Z}_1$  plane as illustrated below:



In other words,  $\bar{s}_3$  determines the positive direction of rotation by the right hand rule and the positive  $Y_1 - Z_1$  plane determines to starting position.

UNITS: (radians per second)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

# PEND3L:

PEND3L is the scalar distance from the hinge line, \$3, to the center of mass of body 3. (i.e. the length of pendulum 3)

'UNITS: (feet)

FORMAT: # 5006 = (1X, F11.5)

# S3(M):

S3(1), S3(2), and S3(3) are the X, Y, and Z components of a unit vector which defines the hinge line of body 3. s<sub>3</sub> is expressed in body 1 coordinates. S3(1) must always be zero.

UNITS: (none)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

# THETA3:

THETA3 is the angle between pendulum 3 and the Y, Z, plane. The axis about which THETA3 rotates is the hinge line s<sub>3</sub>. For an explanation of the THETA3 datum refer to the discussion of OMEGA3.

UNITS: (radians)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

### BODY 4 INPUT VARIABLES

### B4MASS:

B4MASS is the mass of body 4, a pendulum. B4MASS =  $m_{h}$ 

UNITS: (slugs)

FORMAT: # 5004 = (1X, E11.4)

# D14(M):

D14(1), D14(2), and D14(3) are the X, Y, and Z components of the vector from the center of mass of body 1 to the hinge line of body 4.

D14 is expressed in body 1 coordinates.

UNITS: (feet)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

### OMEGA4:

OMEGA4 is the angular velocity of body 4 about the hinge line  $\bar{s}_A$ . OMEGA4 is also the time derivative of THETA4 where the datum for the angle THETA4 is the same as THETA3. (See OMEGA3)

UNITS: (radians per second)

FORMAT: #5006 = (1X, F11.5)

INITIAL VALUE AT TIME = T

### PEND4L:

PEND4L is the scalar distance from the hinge line, \$\vec{s}\_4\$, to the center of mass of body 4. (i.e. the length of pendulum 4)

UNITS: (feet)

FORMAT: #5006 = (1X, F11.5)

# S4(M):

S4(1), S4(2), and S4(3) are the X, Y, and Z components of a unit vector which defines the hinge line of body 4.  $S_4$  is expressed in body 1 coordinates. S4(1) must always be zero.

UNITS: (none)

FORMAT: #5002 = (1X, 3(F11.5, 2X))

# THETA4:

THETA4 is the angle between pendulum 4 and the Y, Z, plane. The axis about which THETA4 rotates is the hinge line  $s_4$ . The datum for THETA4 is the same as for THETA3.

UNITS: (radians)

FORMAT: #5006 = (1x, F11.5)

INITIAL VALUE AT TIME = Tstart

### APPENDIX B, COORDINATE TRANSFORMATIONS

The following pages contain a pictorial guide to aid the user in computing the initial transformation matrix from one right hand orthogonal coordinate system to another. The transformation matrix from coordinate system B to coordinate A shall be denoted [A,B].

Mathematically: 
$$\begin{bmatrix} X_A \\ Y_A \\ Z_A \end{bmatrix} = \begin{bmatrix} A,B \end{bmatrix} \begin{bmatrix} X_B \\ Y_B \\ Z_B \end{bmatrix}$$

i.e. 
$$X_A = AB(1,1) * X_B + AB(1,2) * Y_B + AB(1,3) * Z_B$$

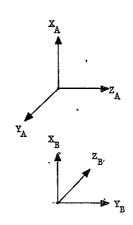
$$Y_A = AB(2,1) * X_B + AB(2,2) * Y_B + AB(2,3) * Z_B$$

$$Z_A = AB(3,1) * X_B + AB(3,2) * Y_B + AB(3,3) * Z_B$$

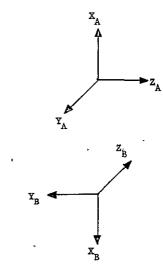
For simplicity, the coordinate systems in the following illustrations are orthogonal to each other in one way or another. i.e. There are not small offsetting rotations. Hence, the components of A,B may assume only certain values. The components may be  $\pm 1.$ , 0.,  $\pm \sin \theta$ ,  $\pm \cos \theta$ ,  $\pm \sin \theta$ ,  $\pm \cos \theta$ ,  $\pm \sin \theta$ , or  $\pm \cos \theta$  where  $\theta$ ,  $\theta$ , and  $\theta$  are angles of rotation about the X, Y, Z axes respectively.

# FLOW CHART & BLOCK DIAGRAM

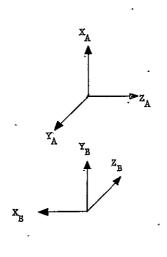
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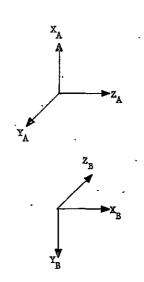
$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 1. & 0. & 0. \\ 0. & 0. & -1. \\ 0. & 1. & 0. \end{bmatrix}$$



$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} -1. & 0. & 0. \\ 0. & 0. & -1. \\ 0. & -1. & 0. \end{bmatrix}$$

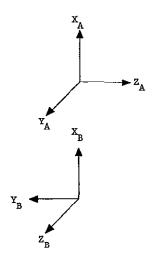


$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 1. & 0. \\ 0. & 0. & -1. \\ -1. & 0. & 0. \end{bmatrix}$$

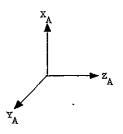


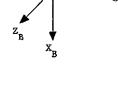
$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0, & -1, & 0, \\ 0, & 0, & -1, \\ 1, & 0, & 0, \end{bmatrix}$$

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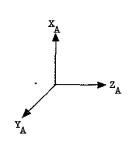


$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 1. & 0. & 0. \\ 0. & 0. & 1. \\ 0. & -1. & 0. \end{bmatrix}$$



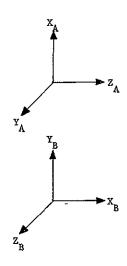


$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} -1, & 0, & 0, \\ 0, & 0, & 1, \\ 0, & 1, & 0. \end{bmatrix}$$





$$\begin{bmatrix} A, & B \end{bmatrix} = \begin{bmatrix} 0. & -1. & 0. \\ 0. & 0. & 1. \\ -1. & 0. & 0. \end{bmatrix}$$

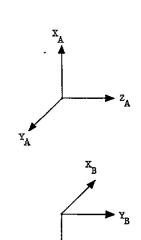


$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0, & 1, & 0, \\ 0, & 0, & 1, \\ 1, & 0, & 0, \end{bmatrix}$$

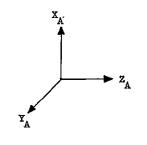
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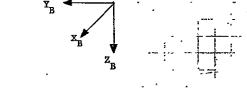
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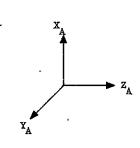


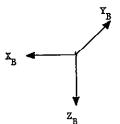
$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 0. & -1. \\ -1. & 0. & 0. \\ 0. & 1. & 0. \end{bmatrix}$$



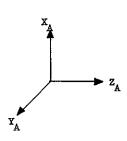


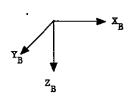
$$\begin{bmatrix} \mathbf{A}, \mathbf{B} \end{bmatrix} = \begin{bmatrix} 0 & 0 & -1 \\ 1 & 0 & 0 \\ 0 & -1 & 0 \end{bmatrix}$$





$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 0. & -1. \\ 0. & -1. & 0. \\ -1. & 0. & 0. \end{bmatrix}$$



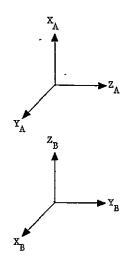


$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0, & 0, & -1, \\ 0, & 1, & 0, \\ 1, & 0, & 0. \end{bmatrix}$$

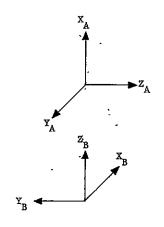
eld

## FLOW CHART & BLOCK DIAGRAM

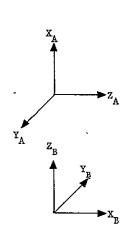
			•		
Application	 	Date	4	Page	of
Procedure		Drawn_Bv			



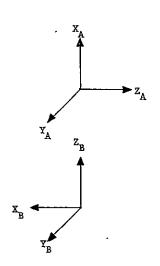
$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0, & 0, & 1. \\ 1. & 0, & 0. \\ 0, & 1. & 0. \end{bmatrix}$$



$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 0. & 1. \\ -1. & 0. & 0. \\ 0. & -1. & 0. \end{bmatrix}.$$



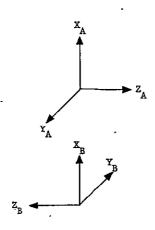
$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 0. & 1. \\ 0. & -1. & 0. \\ 1. & 0. & 0. \end{bmatrix}$$



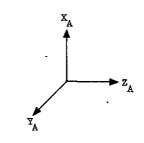
$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 0. & 1. \\ 0. & 1. & 0. \\ -1. & 0. & 0. \end{bmatrix}$$

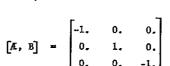
Feld

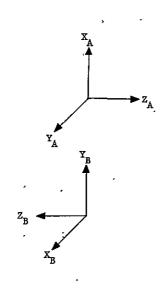
Application	_ Date	
Procedure	Drawn By	



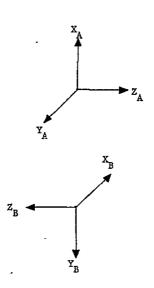
$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 1, & 0, & 0, \\ 0, & -1, & 0, \\ 0, & 0, & -1. \end{bmatrix}$$







$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 1. & 0. \\ 1. & 0. & 0. \\ 0. & 0. & -1. \end{bmatrix}$$

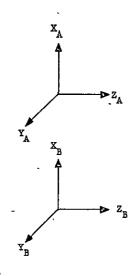


$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & -1. & 0. \\ -1. & 0. & 0. \\ 0. & 0. & -1. \end{bmatrix}$$

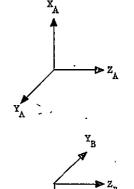
## FLOW CHART & BLOCK DIAGRAM

 Application
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 \_\_\_\_\_\_ Page
 of \_\_\_\_\_\_

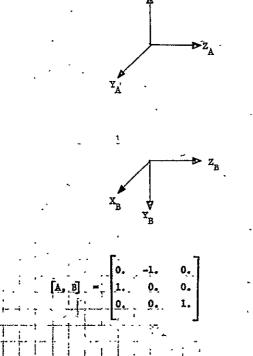
 Procedure
 \_\_\_\_\_\_ Drawn By
 \_\_\_\_\_\_\_

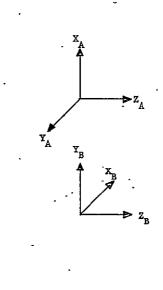


$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 1. & 0. & 0. \\ 0. & 1. & 0. \\ 0. & 0. & 1. \end{bmatrix}$$



$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} -1. & 0. & 0. \\ 0. & -1. & 0. \\ 0. & 0. & 1. \end{bmatrix}$$





$$\begin{bmatrix} A, B \end{bmatrix} = \begin{bmatrix} 0. & 1. & 0. \\ -1. & 0. & 0. \\ 0. & 0. & 1. \end{bmatrix}$$

COMMC

ü 4

```
COMMC
HAPRIM(3)
             H3PRIM(3)
                                                           1 CFB
                                                                            COMMC
                                    TCFA
 COMMON
             182F
                                                           1 DOCK
                                                                            COMMC
                                    ICFO
•
             ICFC
                                                                            COMMC
              IDOF (6)
                                                           IPNTCK
             IGRAVE
                                                                            COMMC
                                    IPNDLM
                                                                            COMMC
                                    IPROPF
             IPRINT
                                    NCHECK
                                                           NDECK

    COMMC

 COMMON
             NCASE
                                                                            COMMC
                                    NUMCMG
             NGAIN
                                                           OMEGA4
                                                                            COMMC
                                    OMEGA3
 COMMON
             OMEGA1
                                                   •
                                                                             COMMC
                                    PEND4L
 COMMON
             PEND3L
                                                                             COMMC
 CUMMON
              Q(4,4)
                                                           R1(3)
                                                                            COMMC
                                    RQ (3)
 COMMON
                                                    •
                                                           RIYSN
                                    RIYCS
                                                                            COMMC
              RIDOT(3)
                                                    ,
                                                            R2:(3)
                                                                             COMMC
                                     RIZSN
              R1ZCS
                                                    •
                                     R2YCS
                                                            R2YSN
4
                                                                             COMMO
              R2DOT(3)
                                                            R3(3)
                                                                             COMMC
              R2ZCS
                                     R2Z5N
                                                                             COMMC
                                     R3YCS
              R3DOT(3)
                                                            R3YSN
                                                                             COMMC
                                     R3Z5N
                                                            R4(3) .
              R3ZCS
                                                            R4YSN
                                                                             COMMC
              RADOT(3)
                                     R4YCS
                                                    ,
                                                                             COMMC
*
                                     R4ZSN
              R4ZCS
                                     SDOT
                                                            SINFEJ
                                                                             COMMC
 COMMON
              S
                                                    .
                                                                             COMMC
                                                            SINTTL
                                     SINTTO
              SINTTJ
                             9
                                                            SINTT4
                                     SINTIS
                                                                             COMMC
Ö
              SINTT2
                             ,
                                                    •
                                                            SUM2
ø
                                                                             COMMC
                                     SUM1
              SP
                                                            53(3)
*
                                     S2 (3)
                                                                             COMMC
              SUM3
                                                    •
                                                                             COMMC
              $4(3)
                                                            TEMP1(3)
                                                                             COMMC
 COMMON
                                     TC(3+3)
              T(3,3)
                                                                             COMMC
              TEMP2(3)
                                     TEMP4 (3)
                                                            TEMP5(3,3)
                                                                             COMMC
              TEMP3(3)
                                                                             COMMC
                                     TEMP7 (3,3)
                                                            TEMP8 (3,3)
              TEMP6(3,3)
                                                    .
                                                            TEMP11 (3,3)
ð
              TEMP9 (3:3)
                                     TEMP10(3.3)
                                                                             COMMC
                                                    •
4
                                                            TEMP14(3.3)
              TEMP12(3,3)
                                     TEMP13(3.3)
                                                                             COMMC
                                                    •
                                                            TERM2(3)
                                                                             COMMC
4
              TEMP15 (3,3)
                                     TERM1(3)
                                                    •
                                                            THATAD (6)
                                     THATA(6)
                                                                             COMMC
              TFRICT
                                                            THE TAG
                                     THETA3
                                                                             COMMC
              THETAL
                                     TIBO(3,3)
                                                            TI801(3,3)
                                                                             COMMC
              THETO
                                                            TJ1(10)
                                     TJ
                                                                             COMMC
              TIME.
                             •
                                                    9
              TJ2(10)
                                     TJ3(10)
                                                            TJ^{4}(10)
                                                                             COMMC
              TMOTOR
                                                                             COMMC
                             ,
                                     TOTMAS
                                                            T01
                                                                             COMMC
              TOEF (3)
                              ŷ
                                                    ,
                                     TOOP (3)
                                                            TQ1G(3)
                                                                             COMMC
              TQOG(3)
                                                    .
                                                            TSTOP
                                                                             COMMC
              TQ1P(3)
                                                            TT4DOT
                                                                             COMMC
                                      TODETT
              TTIDOT
                              •
                                                     .
                                                            T14
                                      713
                                                                              COMMC
              T1EF(3)
  COMMON
                                                                              COMMC
              V (3)
                                      WS.
                                                            W1(3)
                                                                             COMMC
  CUMMON
              WO(3)
 8
                                      #4(3)
                                                                              COMMC
              (E)EW
                                                             XCOOT
                                      XC
                                                                             COMMC
  COMMON
              X(6,7)
                                                                              COMMC
              XMU
                                                                              COMMC
```

THIS IS THE ENTRY POINT TO THE RUN CONTROL MODULE. THE FUNCTION OF THIS MODULE IS TO MAKE THE DECISION TO STOP ALL CALCULATIONS AND EXIT THE PROGRAM OR CONTINUE TO THE INPUT MODULE RCON AND READ IN THE DATA FOR THE NEXT CASE.

NCHECK = 0

RCON

```
READ IN THE NUMBER OF DATA DECKS PRESENT AT RUN TIME.
¢
                                                                         RCON
      READ (5,5000) NDECK
                                                                         RCON
      PRINT NDECK ON A NEW SHEET OF PAPER.
C
                                                                         RCON
      WRITE(6,6000) NDECK
                                                                         RCON .
C
      THE PROGRAM RETURNS TO THE FOLLOWING STATEMENT NUMBER AFTER EACH
                                                                         RCON
C
      DATA DECK HAS BEEN COMPLETELY PROCESSED.
                                                                         RCON
   10 NGHECK = NCHECK + 1
                                                                         RCON
      IF (NDECK .GE. NCHECK) GO TO 20
                                                                         RCON
      STOP
                                                                         RCON
   20 CONTINUE
                                                                         RCON
                                                                         RCON
C
      00000000000
      INPU1
      THIS IS THE ENTRY POINT TO THE INPUT MODULE.
                                                                         INPU1
      THE FUNCTION OF THIS MODULE IS TO READ IN ALL DATA PERTAINING TO
                                                                         INPUT
      THE NEXT CASE. AFTER EACH VARIABLE HAS BEEN READ IN. IT WILL BE
                                                                         INPU
      PRINTED OUT TO INSURE PROPER CONVERSION AND TO RETAIN A RECORD OF INPUT
¢
      THE INPUT DATA.
                                                                         INPU
C
                                                                         INPU
      DO 25 Mal,10
                                                                         TNPU
      GAIN(M) = 0.
                                                                         INPU
   25 CONTINUE
                                                                         INPU'
      WHITE(6,6500) NCHECK
                                                                         INPU'
      READ THE PENDULUM FLAG.
C
                                                                         TNPU'
      READ (5.5000) IPNDLM
                                                                         INPU
      WRITE(6,6082)_IPNDLM
                                                                         INPU.
                            (I.E. PRINT EVERY IPRINT TIME POINT.)
      READ THE PRINT FLAG.
                                                                         INPU
      READ (5,5000) IPRINT
                                                                         INPU'
      WRITE (6.6544) IPRINT
                                                                         INPU'
      READ THE STARTING TIME, STOPING TIME, AND DELTAT.
C
                                                                         INPU'
      READ (5,5002) TSTART.TSTOP.DELTAT
                                                                         INPU'
      WRITE(606002) TSTARTOTSTOPODELTAT
                                                                         INPU'
      READ THE ORBIT ALTITUDE. READ (5,5004) ALT
C
                                                                         INPU'
                                                                         INPU'
      WHITE(6,6004) ALT
                                                                         TNPU'
      READ THE TRANSFORMATION FROM THE BODY O FRAME TO THE I FRAME.
C
                                                                         INPU'
      DU 30 Mal.3
                                                                         INPU'
      DO 30 Na1.3
                                                                         INPU'
      READ (5,5006)
                        TIBOI (M,N)
                                                                         INPU'
   30 CONTINUE
                                                                         INPU'
      DO 35 Male3
                                                                         INPU
      WRITE (6,6006) MoTIBOI (M.1) .M. TIBOI (M.2) .M. TIBOI (M.3)
                                                                         INPU'
   35 CONTINUE
                                                                         TNPU'
C
      READ BODY O ANGULAR RATES.
                                                                         TNPU'
      READ (5,5002) WO(1), WO(2), WO(3)
                                                                         TNPU'
      WRITE(6.6008) WO(1).WO(2).WO(3)
                                                                         INPU'
C
      READ THE MASS OF BODY 0.
                                                                         INPU'
      READ (5,5004)
                      BOMASS
                                                                         INPU'
      Jan
                                                                         TNPU'
      WRITE(6,6010) J.BOMASS
READ THE INERTIA MATRIX FOR BODY 0.
                                                                         TNPU:
C٠
                                                                         TNPU'
      DO 40 Mmle3
                                                                         INPU'
      00 40 Nalo3
                                                                         INPU'
      READ (5.5004)
                        BODYOI (M.N)
                                                                         INPU'
   40 CUNTINUE
                                                                         INPU
      DO 45 Mc1.3
                                                                         INPU'
      WRITE(6,6012) M.BODYOI(M.1).M.BODYOI(M.2).M.BODYOI(M.3)
                                                                         INPU:
   45 CONTINUE
```

INPU'

```
READ THE NUMBER OF CONTROL MOMENT GYROS ABOARD BODY 0.
C
                                                                         INPUT
      READ (5,5000) NUMCMG
                                                                         INPUT
      WRITE(6,6014) NUMCMG
                                                                         INPUT
      IF (NUMCMG .EQ. 0) GO TO 120
                                                                         INPUT
      DO 110 J#1.NUMCMG
                                                                         INPUT
C
      READ THE DEGREE OF FREEDOM OF THE JTH CMG.
                                                                         INPUT
      READ (5,5000) IDOF(J)
                                                                         INPUT
      IF (IDOF(J) .NE. 0) GO TO 50
                                                                         INPUT
      WRITE(6,6016) J
                                                                         INPUT
      GU TO 70
                                                                         INPUT
   50 IF (IDOF(J) .NE. 1) GO TO 60
                                                                         INPUT
      WRITE(6,6018) J
                                                                         INPUT
      GO TO 70
                                                                         INPUT
   60 WHITE(6,6020) J
                                                                         INPUT
   70 CONTINUE
                                                                         INPUT
C
      READ THE ANGULAR MOMENTUM OF THE JTH CMG.
                                                                         INPUT
      READ (5,5004) HW(J)
                                                                         INPUT
      WRITE(6,6022) J.HW(J)
                                                                         INPUT
      READ THE TRANSFORMATION FROM THE JTH NULL GIMBAL FRAME TO BODY O INPUT
C
      FRAME.
C
                                                                         TNPUT
      DO 80 M=1,3
                                                                         INPUT
      DU 80 N=1.3
                                                                         INPUT
      READ (5,5006)
                      AOCJ (J.M.N)
                                                                         INPUT
   BO CONTINUE
                                                                         INPUT
      DO 85 Mal+3
                                                                         INPUT
      WRITE(6:604) J-M-AUCJ(J-M-1):JODA-M-L-(1-M-2) J-M-AUCJ(J-M-3)
                                                                        INPUT
   85 CONTINUE
                                                                        INPUT
      IF (IDOF(J) .EQ. 0)_G0 TO 110
                                                                        TNPUT
                                                                      INPUT
      READ THE INERTIA MATRIX FOR THE JTH INNER GIMBAL.
C
      DO 90 M=1+3
                                                                        ÎNPUT
      DO 90 N=1,3
                                                                        INPUT
      READ (5.5006)
                       (N.M.L) ITA
                                                                         TNPUT
   90 CONTINUE
                                                                         INPUT
      DO 95 Mm1.3
                                                                         INPUT
      WRITE(6,6026) J.M.AII(J.M.1).J.M.AII(J.M.2).J.M.AII(J.M.3)
                                                                        INPUT
   95 CONTINUE
                                                                        INPUT
      READ THE INNER GIMBAL ANGLE AND RATE OF THE JTH CMG.
C
                                                                        INPUT
      READ (5,5006) THATA(J)
                                                                         INPUT
      READ (5.5006) THATAD(J)
                                                                         INPUT
      WRITE(6,6028) J. THATA(J). J. THATAD(J)
                                                                         INPUT
      FEE(J) = 0.
                                                                         INPUT
      FEED(J) = 0.
                                                                         INPUT
      IF (IDOF(J) .EQ. 1) GO TO 110
                                                                         INPUT
C
      READ THE INERTIA MATRIX FOR THE JTH OUTER GIMBAL.
                                                                         INPUT
      00 100 M#1,3
                                                                        INPUT
      DO 100 N=1,3
                                                                        INPUT
      READ (5.5006)
                         AIO(J.M.N)
                                                                        INPUT
  100 CONTINUE
                                                                        INPUT
      00 105 M#1.3
                                                                        INPU
      WRITE(6,6030) J.M.AIO(J.M.1).J.M.AIO(J.M.2).J.M.AIO(J.M.3)
                                                                        INPU:
  105 CONTINUE
                                                                         INPU'
C
      READ THE OUTER GIMBAL ANGLE AND RATE OF THE JTH CMG.
                                                                         INPU'
      READ (5,5006) FEE(J)
                                                                         TNPU'
      READ (5.5006) FEED(J)
                                                                         INPU'
      WRITE(6,6032) J.FEE(J),J.FEED(J)
                                                                         INPU'
  110 CONTINUE
                                                                         INPU'
  120 CONTINUE
                                                                         INPU'
      READ THE PROPULSION FLAG.
C
                                                                         INPU'
      READ (5,5000) IPROPF
                                                                         INPU
      WRITE(6,6072) IPROPF
                                                                         INPU
      IF (IPROPF .EQ. 0) GO TO 140
                                                                         INPU
      READ (5,5000) TATTIF
                                                                         INPU
```

```
INPUT
      WRITE(6,6562) IATTIF
                                                                             INPUT
      IF (IATTIF .EQ. 0) GO TO 125
      READ (5,5002) CA(1) CA(2) CA(3)
                                                                             INPUT
      WRITE(6,6564) CA(1),CA(2),CA(3)
                                                                             INPUT
                                                                             THOUT
  125 CUNTINUE
      00 730 721.3
                                                                             INPUT
      READ (5.5008)
                                                                             INPUT
                       AOJ(J).
                                 CGAINO(J)
                                                                             INPUT
      WKITE(6.6074) J.AOJ(J).J.CGAINO(J)
                                                                             INPUT
  130 CONTINUE
  140 CUNTINUE
                                                                             INPUT
                                                                             INPUT
C
      READ IN VARIABLES RELATED TO BODY 1.
                                                                             INPUT
      READ THE MASS OF BODY 1.
C
      READ (5.5004) BIMASS
                                                                             INPUT
      J = 1
                                                                             INPUT
                                                                             INPUT
      WRITE(6,6010) J.BIMASS
      READ THE INERTIA MATRIX FOR BODY 1.
                                                                             INPUT
Ç
      00 150 Mml,3
                                                                             INPUT
                                                                             INPUT
      DO 150 N#1.3
      READ (5,5004)
                         BODYII (MON)
                                                                             INPUT
  150 CONTINUE
                                                                             INPUT
                                                                             INPUT
      00 153 M=1.3
      WKITE(6,6040) M,BODYII(M,1),M,BODYII(M,2),M,BODYII(M,3)
                                                                             INPUT
  153 CONTINUE
                                                                             INPUI
      READ THE PRIMARY GIMBAL ANGLE AND RATE OF BODY 1 WOROTO BODY 0.
                                                                             INPUT
C
      READ (5.5006) THETAL
                                                                             INPUT
      READ (5,5006) OMEGAI
                                                                             INPUT
      WRITE(6,6042) THETALOMEGAL
                                                                             TNPUT
      READ THE VECTOR FROM THE CM OF BODY 0 TO THE HINGE POINT BETWEEN
                                                                             INPUT
C
      BODY O AND BODY 1. (BODY O COORDINATES)
                                                                             INPUT
                                                                             INPUT
      READ (5,5002) DOI(1),DOI(2),DOI(3)
      WKITE(6,6044) DO1(1),DO1(2),DO1(3)
                                                                             INPUT
C
      READ THE BODY 2 FLAG. (I.E. THE ELEVATOR FLAG.)
                                                                             INPUT
                                                                             TURNT
      READ (5.5000) 182F
      WRITE(6,6546) 182F
                                                                             TNPUT
       IF (IB2F .EQ. 0) GO TO 155
                                                                             INPUT
      READ THE MASS OF THE ELEVATOR.
                                                                             INPUT
C
       READ (5.5004)
                        B2MASS
                                                                             - INPUT
       J = 2
                                                                             INPUT
      WRITE(6,6010) J.BZMASS
                                                                              INPUT
       READ (5,5002) D12(1) D12(2) D12(3)
                                                                             INPUT
       WRITE(6,6535) D12(1) oD12(2) oD12(3)
                                                                             INPUT
                        $2(1), $2(2), $2(3)
       READ (5,5002)
                                                                              TUQUE
       J 🖘 2
                                                                             INPUT
       WRITE(6,6052) J. S2(1), J. S2(2), J. S2(3)
                                                                             INPUI
       HEAD THE POSITION AND VELOCITY OF THE ELEVATOR.
C
                                                                             INPUT
       READ (5.5002) S.SDOT
                                                                             INPUT
       WRITE (6.6548) S.SDOT
                                                                             INPUT
       GO TO 157
                                                                             INPUT
   155 BZMASS # 0.
                                                                             INPUT
       012(1) # 0.
                                                                              INPUT
       D12(2) = 0.
                                                                              INPUT
                                                                              INPUT
       D15'(5) = 0.9
       $2(1) = 0.
                                                                              INPUT
       $2(2) = 0.
                                                                              INPUT
       $2(3) = 0.
                                                                              INPUT
      SDOT = 0.
                                                                              INPUT
       S = 0,
                                                                              INPUT
   157 CONTINUE
                                                                            . INPUT
       IF (IPROPF .EQ. 0) GO TO 170
                                                                              INPUT
       DO 160 J=1,2
                                                                              INPUT.
                        A1J(J) 9
       READ (5,5008)
                                  CGAINI(J)
                                                                              INPUT
       WRITE(6,6076) J,AlJ(J),J,CGAIN1(J)
                                                                              INPUT
```

```
160 CONTINUE
                                                                           TNPUT
  170 CONTINUE
                                                                           TNPUT
                                                                           INPUT
      IF (IPNDLM .EQ. 0) GO TO 172
      READ (5.5004) CP1
                                                                           INPUT
      WRITE(6,6582) CPl -
                                                                           INPUT
      READ (5,5004) CP2
                                                                           TNPUT
      WRITE(6,6584) CP2
                                                                           INPUT
C
      READ THE VARIABLES ASSOCIATED WITH BODY 3. (I.E. PENDULUM 3)
                                                                           INPUT
C
      READ THE MASS OF BODY 3.
                                                                           INPUT
      READ (5,5004)
                       B3MASS
                                                                           TUPUT
      J a. 3
                                                                            INPUT
      WHITE (6,6010) J.B3MASS
                                                                            TNPUT
¢
      READ THE VECTOR FROM THE CM OF BODY 1 TO THE HINGE POINT BETWEEN
                                                                            INPUT
C
      BUDY 1 AND PENDULUM 3. (BODY 1 COORDINATES)
                                                                            TNPUT
      READ (5,5002) D13(1),D13(2),D13(3)
                                                                            INPUT
      WRITE(6,6048) D13(1),D13(2),D13(3)
                                                                            TNPUT
      READ (5.5002) S3(1), S3(2), S3(3)
                                                                            INPUT
      J # 3
                                                                            TNPUT
      WRITE(6,6052) J.S3(1),J,S3(2),J,S3(3)
                                                                            INPUT
      READ THE LENGTH OF BODY 3. (I.E. PENDULUM 3)
Ç,
                                                                            INPUT
      READ (5,5006) PEND3L
                                                                            INPUT
      WKITE (6.6058) PEND3L
                                                                            INPUT
C
      READ THE PRIMARY GIMBAL ANGLE OF BODY 3 WOROT. BODY 10
                                                                           INPUT
      READ (5,5006) THETAS
                                                                            INPUI
      WRITE(6.6060) THETAS
                                                                            TUPUT
C
      READ THE PRIMARY GIMBAL RATE OF BODY 3 WOR. T. BODY 10
                                                                            INPUT
      READ (5,5006) OMEGA3
                                                                            INPUI
      WRITE (6.6062) OMEGA3
                                                                            THPUT
¢
      READ THE VARIABLES ASSOCIATED WITH BODY 4. (I.E. PENDULUM 4)
                                                                            INPUT
C.
      READ THE MASS OF BODY 4.
                                                                            INPUT
      READ (5.5004)
                       B4MASS
                                                                            INPUT
      j 28 46.
                                                                            TNPUT
      WRITE(6,6010) J.B4MASS
                                                                            INPUT
Ç
      READ THE VECTOR FROM THE CM OF BODY 1 TO THE HINGE POINT BETWEEN
                                                                            INPUT
      BODY 1 AND PENDULUM 4. (BODY 1 COURDINATES)
                                                                            INPUI
      READ (5,5002) D14(1),D14(2),D14(3)
                                                                            TUPUT
      WRITE(6.6050) D14(1):014(2):014(3)
                                                                            INPUT
      READ (5.5002)
                       S4(1), S4(2), S4(3)
                                                                            INPUT
      J = 4
                                                                            TNOUT
      WRITE(6,6052) J,S4(1),J,S4(2),J,S4(3)
                                                                            INPUT
C
      READ THE LENGTH OF BODY 4. (I.E. PENOULUM 4)
                                                                            INPUT
      READ (5,5006) PEND4L
                                                                            INPUT
      WRITE(6,6064) PEND4L
                                                                            TNPUT
      READ THE PRIMARY GIMBAL ANGLE AND RATE OF BODY 4 W.R.T. BODY 1.
C-
                                                                            INPUT
      READ (5,5006) THETA4
                                                                            TNPUT
      READ (5,5006) OMEGA4
                                                                            INPUT
      WRITE (6,6066) THETA4,0MEGA4
                                                                            INPUT
      GO TO 174
                                                                            TNPUT
  172 BJMASS # 0.
                                                                            TNPUT
      CP1 = 0.
                                                                            INPUT
      CP2 # 0.
                                                                            INPUT
      D13(1) = 0.
                                                                            INPUI
      D33(2) # 0.
                                                                            INPUT
      D)3(3) = 0.
                                                                            INPUT
      S^3(1) = 0
                                                                            INPUT
      $3.(2) = 0.
                                                                            INPUT
      53(3) = 0.
      PEND3L = 0.
                                                                            TNPUT
      THETA3 = 0.
                                                                            TNPUT
      OMEGA3 = 0.
      B4MASS = 0.
      D14(1) = 0.
```

INPUT

INPUT

INPUT

INPUT

```
ÍNPUŤ
     014(5) = 0
                                                                       INPUT
     014(3) # 0.
                                                                       INPUT
     S4(1) # 0.
                                                                       INPUT
     S4(2) # 0.
                                                                       INPUT
     S4(3) # 0.
                                                                       INPUT
     PENDAL = 0.
                                                                       INPUT
     THETAS . O.
                                                                       INPUT
     OMEGAS # 0.
                                                                       INPUT
 174 CONTINUE
                                                                       INPUT
     READ (5,5006) SP
                                                                       INPUT
     WRITE(6,6080) SP
                                                                       INPUT
     READ (5.5000) NGAIN
                                                                       INPUT
     WRITE (6.6570) NGAIN
                                                                       INPUT
       (NGAIN EQ. 0) GO TO 176
                                                                       INPUT
     DO 175 J=1.NGAIN
                                                                       INPUT
     READ (5,5004) GAIN(J)
                                                                       INPUI
     WHITE (6.6572) J.GAIN(J)
                                                                       INPUT
 175 CONTINUE
                                                                       INPUT
  176 CONTINUE
                                                                       INPUT
     READ THE GRAVITY GRADIENT FLAG.
C
                                                                       INPUT
     READ (5,5000) IGHAVF
                                                                       INPUT
      WHITE(6,6078) IGRAVF
     READ THE DOCKING FLAG. IDOCK = 1 IMPLIES A DOCKING WILL OCCUR.
                                                                       INPUT
C
                                                                       TNPUT
      READ (5,5000) IDOCK
                                                                       INPUT
      WHITE (6,6068) IDOCK
                                                                       INPUT
      IF (IDOCK .EQ. 0) GO TO 180
                                                                       INPUT
      READ THE TIME OF DOCKING.
C
      READ (5,5006) DTIME
                                                                       INPUT
                                                                       INPUT
      WRITE(6,6070) DTIME
                                                                       INPUT
      DIMIN = DIIME - DELTAT/10.
                                                                       INPUT
      DTHAX = DTIME + DELTAT/10.
                                                                       INPUT
      DCHMIN = DTIME - 1.10DELTAT
                                                                       INPUT
      DCHMAX = DTIME - 0.94DELTAT
                                                                       TNPUT
      READ (5,5004) BDMASS
                                                                        TNPUT
      WRITE(6,6574) BDMASS
                                                                        INPUT
      DO 177 M=1,3
                                                                       INPUT
      DO 177 N=1,3
                                                                        INPUT
      READ (5,5004) BODYDI (MON)
                                                                        INPUT
  177 CONTINUE
                                                                       INPUT
      DO 178 M=1.3
                                                                       INPUT
      WRITE(6,6576) M.BODYDI(M.1), M.BODYDI(M.2), M.BODYDI(M.3)
                                                                       INPUT
  178 CONTINUE
      READ (5,5002) DTI(1),DTI(2),DTI(3)
                                                                        INPUT
                                                                        INPUT
      WRITE(6,6578) DTI(1).DTI(2).DTI(3)
                                                                        INPUT
      READ (5,5002) DD01(1),DD01(2),DD01(3)
      WRITE (6, 6586) DDO1(1), DDO1(2), DDO1(3)
                                                                        INPUT
                                                                        INPUT
  180 CONTINUE
                                                                        TNPUT
000000000000
      ö
      INIT
      THIS IS THE ENTRY POINT TO THE INITIALIZATION BLOCK.
                                                                        INIT
      ALL INITIAL CALCULATIONS ARE PERFORMED ONE TIME ONLY FOR EACH CASEINIT
                                                                        INIT
      CALCULATE THE TOTAL MASS OF THE CONFIGURATION.
                                                                        INIT
      TOTMAS & BOMASS + BIMASS + BIMASS + BIMASS + BAMASS
                                                                        INIT
                                                                        INIT
       ICFA & 0
                                                                        INIT
       ICFB = 0
                                                                        INIT
       ICFC so o
```

```
ICFD = 0
                                                                                  INÍT
C
      INITIALIZE THE FLAGS NEEDED TO START THE INTEGRATIONS.
                                                                                  INIT
      FLAG1 = 0.
                                                                                  INIT
      FLAG2 # 0.
                                                                                  INIT
      FLAG3 # 0.
                                                                                  TNIT
      FLAG4 # 0.
                                                                                  INIT
C
       INITIALIZE THE QUATERNION COMPONENTS.
                                                                                  THIT
      AE(2) # 1.
                                                                                  INIT
      AE(3) = 0.
                                                                                  INIT
      AE(4) = 0.
                                                                                  INIT
      AE.(5) 8 0.
                                                                                  INIT
       AED(2) = 1.
                                                                                  INIT
      AED(3) = 0.
                                                                                  INTT
      AED(4) z
                 0.
                                                                                  INIT
      AED(5) = 0.
                                                                                  INIT
       ATWO(2) = THETA1
                                                                                  INIT
       ATWO(3) = THETA3
                                                                                  INIT
      ATWO(4) # THETA4
                                                                                  INIT
       ATHREE(2) # 1.0
                                                                                  INIT
       ATHREE (3) $ 0.0
                                                                                  INIT
      ATHREE (4) = 0.0
                                                                                  INIT
       ATHREE(5) # 0.0
                                                                                  INIT
C.
       INITIALIZE THE PRINT CHECK FLAG.
                                                                                  INIT
       IPNTCK = 1
                                                                                  INIT
       TAP a 0.
                                                                                  INIT
       TBP . 0.
                                                                                  INIT
C
       INITIALIZE TIME TO THE TSTART VALUE.
                                                                                  INIT
       TIME & TSTART
                                                                                  INIT
      XMU = 1.408E+16
                                                                                  INIT
       R # ALT + 3960.
                                                                                  INTT
       R #: 5280.4R
                                                                                  INIT
       Cl = XMU/R++3
                                                                                  INIT
       WS # SORT(C1)
                                                                                  INTT
       EEE(1.1) = 0.
                                                                                  INIT
       EEE(1.2)
                 z O.
                                                                                  INIT
      EEE(1,03)
                 = 0.
                                                                                  INIT
      EEE (2.1) =
                   0 .
                                                                                  INIT
      EEE (2,2)
                 靍
                                                                                  INIT
      EEE (2,3) =
                                                                                  INIT
       EEE:(3.1)
                靐
                   0.
                                                                                  INIT
      EEE:(3,2)
                 a. 0.
                                                                                  INIT
       EEE (3,3)
                 8 O.
                                                                                  INIT
      FFF(1) #
                 0 .
                                                                                  INIŢ
      FFF42) =
                                                                                  INIT
       FFF(3) = 0.
                                                                                  INIT
      FO1(1) = 0.
                                                                                  INIT
       FO1(2) # 0,
                                                                                  INIT
      FO1(3) = 0.
                                                                                  INIT
                # O.
      F02:(1)
                                                                                  INIT
      F0842)
                  0.0
                                                                                  INIT
       FO2(3)
                8
                  0.
                                                                                  INIT
      FO(3)
              = 0.
                                                                                  INIT
       FO-(2)
              g 0 .
                                                                                  INIT
       FO (3)
              . 10 e
                                                                                  INTT
       F11(1)
              тя: О "
                                                                                  INIT
       F11 (2)
              E. 0.
                                                                                  INIT
      F11(3)
              22
                                                                                  INIT
       F12(1)
                B. 0 .
                                                                                  INIT
       F12:(2)
                  0.
                                                                                  INIT
       F12(3)
                3
                  0.
                                                                                  INIT
       F1(1)
              # 0.
                                                                                  INIT
              E 0.
       F1 (2)
                                                                                  INIT
```

```
F1(3)
                                                                  INIT
      TQ0G(1) # 0.
                                                                  INIT
      Id00(5)
                                                                  INIT
      TWOG(3)
                                                                  INTT
             # O.
      TOOP(1)
                                                                  INIT
      140P(2)
                                                                  IÑIT
      TWOP(3)
                                                                  INIT
               0.
      TQ10(1)
             8
                                                                  INIT
      T416(2) =
                                                                  INIT
               0.
      Tw16(3) =
                                                                  INIT
      TQ1P(1) .=
                                                                  INIT
               0.
      TW1P(2) =
                                                                  INIT
      TW1P(3) = 0.
                                                                  ĬNĬŢ
      IF (NUMCMG .EQ. 0) GO TO 184
                                                                  INIT
      CALL CMG
                                                                  INIT
      DO 183 JET NUMCHG
                                                                  INIT
      THATA(J) # THATA(J) # THATAD(J)#DELTAT
                                                                  INIT
      FEE(J) # FEE(J) # FEED(J) #DELTAT
                                                                  INIT
  183 CONTINUE
                                                                  INIT
  184 CONTINUE
                                                                   INIT
      SUBROUTINE XDOT CALCULATES THE FOLLOWING VARIABLES.
 00000
                                                                   INIT
           Α.
               HDOT (1)
                                                                  INIT
           8.
               HDOT (2)
                                                                  INIT
           Co
               HDOT (3)
                                                                   INIT
           D.
               HIPDOT(1)
                                                                  INII
 C
               GBDOT
           E.
                                                                   INIT
 C
           F.
               G4DOT
                                                                   INIT
      CALL XDOT
                                                                   INIT
 0000000
                                                                   INIT
      ø
      4
      #
      190 CONTINUE
 0000000000
      *
      *
      INTEG
      THIS IS THE ENTRY POINT TO INTEGRATION BLOCK ONE.
                                                                   INTEG
      THE PURPOSE OF THE BLOCK IS TO CALL AN INTEGRATION SUBROUTINE TO
                                                                   INTEG.
      INTEGRATE THE VARIABLES CALCULATED BY SUBROUTINE XDOT.
                                                                  INTEG
 C
      THE ARRAYS USED BY THE INTEGRATION SUBROUTINE MUST BE! CALCULATED
                                                                   INTEG
      EACH TIME BEFORE CALLING THE INTEGRATION SUBROUTINE.
                                                                   INTEG
- C
                                                                   INTEG
      IF (TIME .NE. TSTART) GO TO 192
                                                                   INTEG.
      CALL EMCALC
                                                                   INTEG
      G3
           = EM(5,1) ↔₩O(1)
                           4 EM(5.2) *WO(2)

◆ EM(5,3) ♥₩0(3)

                                                                  INTEG
            +EM (5,4) +OMEGA1 + EM (5,5) +OMEGA3 + EM (5,6) +OMEGA4
                                                                  INTEG
      G4
           # EM(6,1) $\\O(1)

♦ EM(6,2)♦WO(2)

                                          + EM(6.3) #WO(3)
                                                                  INTEG
            +FM(6.4) +OMEGA1 + EM(6.5) +OMEGA3 + EM(6.6) +OMEGA4
                                                                  INTEG
   192 CONTINUE
                                                                   INTEG
      AUNE(1) = TIME
                                                                   INTEG
      AUNE(2) = H(1)
                                                                   INTEG
      AONE(3) = H(2)
                                                                   INTEG
      AONE(4) = H(3)
                                                                   INTEG
      AONE(5) = HIPRIM(1)
                                                                   INTEG
      AUNE(6) = G3
                                                                   INTEG
```

```
INTEG
     AONE (7) 8 64
                                                                       INTEG
     BUNE(1) = DELTAT
                                                                       INTEG
     BONE(S) = HDOL(1)
                                                                      INTEG
     BUNE(3) = HDOT(2)
                                                                       INTEG
     BONE(4) # HDOT(3)
                                                                       TMTEG
     BUNE (5) = HIPDOT (1)
                                                                       INTEG
     BUNE(6) = G3DOT
     BUNE (7) = G4DOT
                                                                       INTEG
     CALL FOMS (AQNE, BONE, 7, FLAGI, TJ1)
                                                                       INTEG
                                                                       INTEG
     H(1)
               m AONE(2)
                                                                       INTEG
     H(2)
               m AONE (3)
                                                                       INTEG
     K(3)
               # AONE (4)
     IF (IDOCK .EQ. 0) GO TO 193
                                                                       INTEG
     IF ((TIME .LT. DCHMIN) .OR. (TIME .GT. DCHMAX)) GO TO 193
                                                                       INTEG
                                                                       INTEG
     H(1) = H(1) + DTI(1)
                                                                       INTEG
     H(2) = H(2) + DTI(2)
     H(3) = H(3) \Rightarrow DTI(3)
                                                                       INTEG
  193 CONTINUE
                                                                       INTEG
      HIPRIM(1) = AONE(5)
                                                                       INTEG
               B AONE (6)
                                                                       INTEG
                                                                       INTEG
      Ġ4
               m AONE (7)
                                                                       INTEG
00000000000
      ****************
      #
      THIS SEGMENT SIMPLY CALCULATES THE GIMBAL ANGLE RATES: OF BODIES ONE THREE, AND FOUR. THAT IS TO SAY THE SUBSTITUTION NEEDED BY
      INTEGRATION BLOCK TWO IS DONE AT THIS POINT.
      TT1DOT = OMEGA1
TT3DOT = OMEGA3
      TT4DOT # OMEGA4
¢
Ċ
      σσσσάσσσοσ
      ø
      INTEG
      THIS IS THE ENTRY POINT TO INTEGRATION BLOCK TWO.
                                                                       INTEG
      THE PURPOSE OF THE BLOCK IS TO CALL AN INTEGRATION SUBROUTINE TO
                                                                       INTEG
      INTEGRATE THE GIMBAL ANGLE RATES OF BODIES ONE, THREE, AND FOUR TO PRODUCE THE CORRESPONDING GIMBAL ANGLE POSITIONS. AS BEFORE, THE ARRAYS USED BY THE INTEGRATION SUBROUTINE MUST BE CALCULATED
                                                                       INTEG
                                                                       INTEG
                                                                       INTEC
                                                                       INTEG
C
      EACH TIME BEFORE CALLING THE INTEGRATION SUBROUTINE.
                                                                       INTEG
      ATWO(1) - TIME
                                                                       INTEG
      BTWO(1) = DELTAT
                                                                        INTEG
      BTWO(2) = TTIDOT
                                                                       INTEG
      BTWO (3) = TT3DOT
                                                                        INTEG
      BTWO(4) = TT4DOT
                                                                        INTEG
      CALL FOMS (ATWO.BTWO.4.FLAG2.TJZ)
                                                                       INTEG
      THETAL - ATWO(2)
                                                                        INTEG
      THETA3 # ATMO(3)
                                                                        INTEG
      THETA4 = ATHO(4)
                                                                       INTEG
C
                                                                        INTE(
Ċ
      C١
```

```
00000
```

C

```
GUAT
     THIS IS THE ENTRY POINT TO THE QUATERNION BLOCK.
                                                                           CUAT
                                                                           QUAT
     Q(1+1) m
                                                                           QUAT
                0,0
                                                                           QUAT
            m =0.5+WO(1)
     0(1.2)
            = =0.5#WO(2)
                                                                           QUAT
      G(1.3)
                                                                           QUAT
            m =0.5+WO(3)
      U(194)
                                                                           QUAT
      0(201)
            # a0(1.5)
                                                                           DUAT
      u(2,2)
             0.
                                                                           GUAT
      Q(2.3)
            m =0(1,4)
                                                                           QUAT
      9(2+4)
                Q(1,3)
            QUAT
      Q(3+1) = -Q(1+3)
                Q(1.4)
                                                                           QUAT
      4(3.2) m
                                                                           QUAT
      (2 · 3 · 3)
                0.
                                                                           QUAT
      Q(3+4) = -Q(1+2)
                                                                           QUAT
      Q(4+1) = -Q(1+4)
                                                                           QUAT
      Q(4,2) = -Q(1,3)
                                                                           QUAT
      Q(4.3)
             Q(1.2)
                                                                           QUAT
      Q(4,4) =
      AED(2) = Q(1,1) + AE(2) + Q(1,2) + AE(3) + Q(1,3) + AE(4) + Q(1,4) + AE(5) QUAT
      AED(3) = Q(2.1) #AE(2) + Q(2.2) #AE(3) + Q(2.3) #AE(4) + Q(2.4) #AE(5) QUAT
      AED(4) = Q(3,1) *AE(2) + Q(3,2) *AE(3) + Q(3,3) *AE(4) + Q(3,4) *AE(5) QUAT
      AED(5) = Q(4,1) *AE(2) + Q(4,2) *AE(3) + Q(4,3) *AE(4) + Q(4,4) *AE(5) QUAT
      SET UP MATRICES USED BY THE INTEGRATION SUBROUTINE
                                                                           QUAT
C
      ATHREE(1) = TIME
                                                                           QUAT
                                                                           QUAT
      BTHREE(1) = DELTAT
                                                                           QUAT
      BTHREE(2) = AED(2)
                                                                           QUAT
      BTHREE(3) = AED(3)
      BTHREE (4) = AED (4)
                                                                           QUAT
      BTHREE(5) = AED(5)
                                                                           QUAT
      CALL FOMS (ATHREE . BTHREE . 5 . FLAG3 . TJ3)
                                                                           QUAT
                                                                           QUAT
      AE(2) = ATHREE(2)
      AE(3) # ATHREE(3)
                                                                           QUAT
      AE(4) # ATHREE(4)
                                                                           QUAT
      AE(5) # ATHREE(5)
                                                                           QUAT
C
      CALCULATE THE NORMALIZING FACTOR.
                                                                           QUAT
      FN = SQRT( AE(2) 000 + AE(3) 002 + AE(4) 002 + AE(5) 002 )
                                                                           QUAT
                                                                           QUAT
      AE(2) # AE(2)/FN
      AE(3) = AE(3)/FN
                                                                           QUAT
      AE.(4) # AE(4)/FN
                                                                           QUAT
      AE (5) # AE (5) /FN
                                                                           QUAT
      T(1.1) = AE(2) 442 + AE(3) 442 - AE(4) 442 - AE(5) 442
                                                                           QUAT
      T(lo2) = 2.4(AE(3)AE(4) - AE(2)AE(5))
                                                                           QUAT
      T(1.3) = 2.*(AE(3)*AE(5) * AE(2)*AE(4))
                                                                           QUAT
      T(2,1) = 2.0(AE(3)0AE(4) + AE(2)0AE(5))
                                                                           QUAT
      T(2+2) = AE(2) + P2 - AE(3) + P2 + AE(4) + P2 - AE(5) + P2
                                                                           QUAT
      T(203) = 2.0(AE(4)0AE(5) - AE(2)0AE(3))
                                                                           QUAT
      T(3,1) = 2. + (AE(3) AE(5) - AE(2) AE(4))
                                                                           QUAT
      T(3.2) = 2. + (AE(4) +AE(5) + AE(2) +AE(3))
                                                                           QUAT
      T(3,3) # AE(2) ##2 # AE(3) ##2 - AE(4) ##2 + AE(5) ##2
                                                                           QUAT
      CALL MULT (DUM. DUM. DUM, TIBO. TIBOT, T.2)
                                                                           QUAT
      CALL MULT(HI.TIBO, H.DUM, DUM, DUM, 1)
                                                                           QUAT
                                                                           QUAT
0000000
      *
      *
      我的感情的情况我们的现在分词我们的特殊的的现在分词,这些的特殊的特殊的特殊的特殊的特殊的特殊的的特殊的特殊的特殊的。
                                                                            CONTA
```

\*\*\*\*

CONTA

THIS IS THE ENTRY POINT TO CONTM

```
CONTM
C
      IF (NUMCMG .EQ. 0) GO TO 195
                                                                                CONTM
                                                                                 CONTH
      CALL HOON
  195 CUNTINUE
                                                                                 CONTH
                                                                                 CONTP
      FPT(1) = 0.
      FPT(2) - 0.
                                                                                 CONTH
      FPT(3) # 0.
                                                                                 CONTH
                                                                                 CONTR
      FPT(4)
              *
      FPT (5)
                                                                                 CONTH
              # 0.
                                                                                 CONTH
       FAT(1)
              5 0 5
                                                                                CONIM
       FAT(2)
              B 0.
                                                                                 CONTH
       FAT (3)
                                                                                 CONTH
       FAT(4)
              ms () .
       FAT(5)
                                                                                 CONTM
                                                                                 CONTR
       FAT(6)
              s 0.
                                                                                 CONTM
       FAT(7) # 0.
                                                                                 CONTM
       FAT(8) = 0.
                                                                                 CONTM
       DO 196 M#1#3
       TOOP(M) # 0.
                                                                                 CONTM
       TQ1P(M) # 0.
                                                                                 CONTM
  196 CUNTINUE
                                                                                 CONTM
                                                                                 CONTH
       IF (IPROPF .EQ. 0) GO TO 199
       IF (IATTIF ,EQ. 0) GO TO 197
                                                                                 CONIN
                                                                                 CONTH
       CALL ATT
       IF (ICFA .EQ. 1) GO TO 199
                                                                                 CONTM
  197 CONTINUE
                                                                                 CONTM
                                                                                 CONTH
       CALL PCON
   199 CONTINUE
                                                                                 CONTH
       IMP = FAT(1) + FAT(2) + FPT(2) + FPT(3) + FPT(4)
                                                                                 CONTR
       TAP . TAP . TMPODELTAT
                                                                                 CONTH
       \mathsf{TNP} = \mathsf{FPT}(1) + \mathsf{FPT}(5)
                                                                                 CONTM
       TBP = TBP + TNP#DELTAT
                                                                                 CONTM
                                                                                 CONTM
0000000
       你,我们的现在我们的现在分词,我们们的的一个人的,我们们的一个人的,我们们的一个人的,我们的一个人的,我们们的一个人的,我们们的一个人的,我们们的一个人的,我们们的一个人的,我们们们的一个人的,我们们们的一个人的,我们们们的一个人的,我们们们们的一个人的,我们们们们的一个人的,我们可以完全的一个人的。
       INVER
       THIS IS THE ENTRY POINT TO THE INVERSION BLOCK
                                                                                  INVER
 C
                                                                                  INVER
       GALL RECALC
                                                                                  INVER
       CALL EMCALC
                                                                                  INVER
 C
                                                                                  INVER
       SET UP THE X MATRIX
                                                                                  INVER
       DO 200 M#1.6
                                                                                  INVER
                                                                                  INVER
       DO 200 N#1.6
       X(MaN) # EM(MaN)
                                                                                  INVER
   200 CONTINUE
                                                                                  INVER
        STEMP) * B2MASS&SDOT#(*R2(3)*S2(2) + R2(2)*S2(3))
                                                                                  INVER
       STEMP2 # B2MASS#SDOT#((R2(3)#52(1) = R2(1)#52(3))#COSTT1 -
                                                                                  INVER
                                (=R2(2)+S2(1) + R2(1)+S2(2))+SINTT1)
                                                                                  INVER
       STEMP3 # BEMASS&SDOT*((R2(3) &S2(1) - R2(1) &S2(3)) *SINIT1 +
                                                                                  INVER
        (#R2(2) #S2(1) + R2(1) #S2(2) #COSTT1)
STEMP4 # SDOT#(S2(2) #(#82MASS#R2(3) + (BOMASS#B2MASS/JOTMAS)#
                                                                                  INVER
                                                                                  INVER
       * (DO1(2) *SINTT1 - DO1(3) *COSTT1)) + S2(3) *(B2MAS$*R2(2) -
                                                                                  INVEF
       * (BOMASS+BEMASS/TOTMAS) * (DO1(2) *COSTT) + DO1(3) *$INTT1)))
                                                                                  INVEF
        STEMP5 # (B2MASS*B3MASS/TOTMAS)*SDOT*((EL3(3)*$2(1) =
                                                                                  INVER
       * EL3(1)*S2(3))*S3(2) + (*EL3(2)*S2(1) + EL3(1)*S2(2))*S3(3))
                                                                                  INVEF
        STEMP6 = (B2MASS+B4MASS/TOTMAS) +SDOT+ ((EL4(3)+52(1) -
                                                                                  INVER
       # EL4(1)#52(3))#$4(2) + (=EL4(2)#$2(1) + EL4(1)#$2(2))#$4(3)}
                                                                                  INVEF
        H(1) = H(1) = STEMP1
                                                                                  INVER
```

```
H(2) = H(2) = STEMP2
                                                               INVER
     H(3) # H(3) - STEMP3
                                                               inver
     HIPRIM(1) = HIPRIM(1) = STEMP4
                                                               INVER
     G3 # G3 + STEMP5
                                                               INVER
     G4 # G4 + STEMP6
                                                               ÎNVER
     IF (IPNDLM .EQ. 0) GO TO 202
                                                               INVER
     DO 201 M=1.3
                                                               INVEF
     V(M) = H(M) - FFF(M)
                                                               INVEF
 201 CONTINUE
                                                               INVER
     X(1,7) = V(1)
                                                               INVER
     X(297) = V(2)
                                                               INVER
     X(3,7) = V(3)
                                                               INVER
     X(4)7) = H1PRIM(1)
                                                               INVER
     X(597) = G3
                                                               INVER
     X(6+7) = G4
                                                               INVER
     CALL SYERNS (X.6.6.7.FLAG)
                                                               TNVER
             X(1.7)
     WO(1) m
                                                               INVER
     WO(2) B
             X-(207)
                                                               INVER
     MO(3) =
             X(3,7)
                                                               INVER
     OMEGA1 # X(4,7)
                                                               INVER
     OMEGA3 = X(5,7)
                                                               INVER
     OMEGA4 = X(6.7)
                                                               INVER
     GO TO 204
                                                               INVER
 202 CONTINUE
                                                               INVER
     DU 203 M#1.3
                                                               INVER
     V(M) \approx H(M) = FFF(M)
                                                               INVER
 203 CONTINUE
                                                               INVEG
     X(1.5) = V(1)
                                                               INVER
     X(2*5) \neq V(2)
                                                               INVER
     X(3,5) & V(3)
                                                               INVER
     X(495) = HiPRIM(1)
                                                               INVER
     CALL SYEGNS (X+4+6+7+FLAG)
                                                               INVER
     WO(1) = X(1.5)
                                                               INVER
     WO(2) = X(2,5)
                                                               INVER
     WU(3) $ X(3,5)
                                                               INVER
     OMEGA1 = X(4.5)
                                                               INVER
     OMEGA3 # 0.
                                                               INVER
     OMEGA4 # 0.
                                                               INVER
  204 CONTINUE
                                                               INVES
C
                                                               INVER
     00000000
     ¥
     4
     UPDATE TIME
     TIME # TIME . DELTAT
     CALL XDOT
Ĉ
00000000
     Ğ.
     #
     OUTPL
     THIS IS THE ENTRY POINT TO THE OUTPUT BLOCK.
                                                               OUTPL
C
                                                               OUTPL
     IF (IPNTCK .NE. IPRINT) GO TO 215
                                                               OUTPL
C
     SKIP TO A NEW PAGE AND PRINT A LINE OF ASTERICKS.
                                                               OUTPI
     WRITE (6,6502)
                                                               OUTPL
```

```
OUTPL
    WRITE (6,6504) TIME
    IF (IDOCK .EQ. 0) 60 TO 208
                                                                             OUTPL
    IF ((TIME.LT.DTMIN).OR. (TIME.GT.DTMAX)) GO TO 208
                                                                             OUTPU
                                                                             OUTPE
    WRITE (6,6580)
                                                                             OUTPL
    IDOCK # 0
208 CONTINUE
                                                                             OUTPU
                                                                             OUTPU
    WHITE (6,6550)
    WRITE(6,6510) H(1) oH(2) oH(3)
                                                                             OUTPU
                                                                             OUTPU
    WAITE(6,6514) HDOT(1), HDOT(2), HDOT(3)
                                                                             UGTUG
    WRITE(6,6512) HI(1),HI(2),HI(3)
                                                                             OUTPU
    DO 207 M#1.3
                                                                             OUTPU
    (E.M) OBITEM. (Sem) OBITEM. (Jem) OBITEM (BEED, 6) 3TIHW
207 CONTINUE
                                                                             OUTPU
                                                                             OUTPU
    WRITE (6,6536) THETO, TOTMAS
                                                                             OUTEU
    J 8 0
                                                                             OUTPU
    WRITE(6.6552) J
                                                                             OUTPU
    WRITE(6,6008) WO(1),WO(2),WO(3)
                                                                             OUTPU
    J # 0
    WRITE(6,6526) J.RO(1).J.RO(2).J.RO(3)
                                                                             OUTPU
    WRITE (6,6554)
                                                                             OUTPU
                                                                             OUTPU
    J 8: 1
                                                                             OUTPU
    WRITE (6,6552)
                                                                             OUTPU
    WRITE(6,6506) J. WI(1), J. WI(2), J. WI(3)
                                                                             OUTPU
    WRITE(6,6526) J.R1(1),J.R1(2),J.R1(3)
    WRITE(6,6528) J.RIDOT(1),J.RIDOT(2),J.RIDOT(3)
                                                                             OUTPU
    WRITE (6,6042) THETAL OMEGAL
                                                                             OUTPL
    WRITE (6,6554)
                                                                             MUTPL
     IF (IB2F .EQ. 0) GO TO 209
                                                                             OUTPL
     J 8: 2
                                                                             OUTPL
    WRITE(6,6552) J
                                                                             OUTPL
    WRITE(6,6556) 5,500T
                                                                             OUTPU
                    J, EL2(1), J, EL2(2), J, EL2(3)
    WRJTE(6,6522)
                                                                             OUTPL
    WRITE (6,6524)
                    J, EL2007(1), J, EL2007(2), J, EL2007(3)
                                                                             OUTEL
     WRITE(6,6526) J.R2(1),J.R2(2),J.R2(3)
                                                                             OUTPU
     WRITE(6.6528) J.R2DOT(1).J.R2DOT(2).J.R2DOT(3)
                                                                              OUTPU
209' CONTINUE
                                                                              OUTPL
     WHITE (6,6554)
                                                                              OUTPU
     IF (IPNDLM .EQ. 0) GO TO 211
                                                                              OUTPL
     J. a 3
                                                                              OUTPL
     WRITE (6,6552)
                                                                              OUTPL
     (E) EHele (2) EHele (1) EHel (60666) 3717H
                                                                              OUTPU
     WRITE(6.6516) J. HaPRIM(1) . J. HaPRIM(2) . J. HaPRIM(3)
                                                                              OUTPL
     WRITE(6,6522) J.EL3(1), J.EL3(2), J.EL3(3)
                                                                              OUTPL.
     WRITE(6,6524)
                    J,EL3DOT(1), J,EL3DOT(2), J,EL3DOT(3)
                                                                              OUTPU
     WRITE(6,6526)
                    16) ERole (S) ERole (1) ERol
                                                                              OUTPL
                    J.R3DOT(1) .J.R3DOT(2) .J.R3DOT(3)
     WRITE(6,6528)
                                                                              OUTPL
     WRITE(6,6558) JOTHETA3.J.OMEGA3
                                                                              OUTPL
     WRITE (6,6560)
                    J.G3.J.G3DOT
                                                                              OUTPL
     Write (6,6554)
                                                                              OUTPL
     J. # 6
                                                                              OUTPL
     WRITE (6.6552)
                                                                              OUTPL
     WRITE (6,6506)
                    16) 4We(1) . JoW4(2) . JoW4(3)
                                                                              OUTPL
     WRITE (6.6516)
                    JoH4PRIM(1) .J.H4PRIM(2) .J.H4PRIM(3)
                                                                              OUTPL
     WRITE (6.6522)
                    JoEL4(1), JoEL4(2), JoEL4(3)
                                                                              OUTPL
     WRITE (6,6524)
                    J,EL4DOT(1),J,EL4DOT(2),J,EL4DOT(3)
                                                                              OUTPL
     WRITE (6.6526)
                     J&R& (1), J9R4 (2), J9R4 (3)
                                                                              OUTPU
     WRITE (6,6528)
                     J.R4DOT (1) .J.R4DOT (2) .J.R4DOT (3)
                                                                              OUTPL
     WHITE (6,6558)
                    J. THETA4. J. UMEGA4
                                                                              OUTPL
     #RITE(6,6560) J,64,J,64DOT
                                                                              OUTPL
 211 CONTINUE
                                                                              OUTPL
     IF (IPROPF .EQ. 0) GO TO 212
                                                                              OUTPL
     HRITE(6.6588) TAP
                                                                              OUTPL
```

```
OUTPL
     WRITE(6,6590) TBP
 212 CONTINUE
                                                                     OUTPL
     IF (NUMCMG .EQ. 0) GO TO 214
                                                                     OUTPL
                                                                     OUTPL
     DO SI3 J=1.NUMCMG
     WHITE (6,6028) J. THATA(J) .J. THATAD(J)
                                                                     OUTPL
        (IDOF(J) .NE. 2) GO TO 213
                                                                     OUTPL
     WRITE(6,6032) J.FEE(J),J.FEED(J)
                                                                     OUTPL
 213 CONTINUE.
                                                                     OUTPI.
 214 CUNTINUE.
                                                                     OUTPL
     IPNTCK = 0
                                                                     OUTPL
  215 IPNTCK = IPNTCK + 1
                                                                     OUTPL
¢
                                                                     OUTPL
     ***********************
Č
¢
¢
¢

[F (IDOCK NE. 1) 60 TO 220
      IF((TIME.LT.DCHMIN).OR.([IME.GT.DCHMAX)) GO TO 220
      DO 218 M#1.3
      DU 218 N=1.3
      BODYOI(M,N) = BODYDI(M,N)
  218 CONTINUE
      BOMASS = BOMASS
      DOI(1) = DDOI(1)
      DOl(2) = DDOl(2)
      DO1(3) = DD01(3)
      TUTMAS = BOMASS + BIMASS + BZMASS + B3MASS + B6MASS
      GU TO 190
  220 IF (TIME .GT. TSTOP) GO TO 10
      GO TO 190
      C
Ç
      4
CCC
      C
      THIS SECTION CONTAINS ALL OF THE INPUT AND OUTPUT FORMATS.
                                                                      1/0
                                                                      1/0
 5,000 FORMAT(1X,12)
                                                                      1/0
 5002 FORMAT(1X,3(F11.5,2X))
                                                                      I/O
 5004 FURMAT(1X,E11.4)
                                                                      I/0
 5000 FURMAT(1X.F11.5)
                                                                      1/0
                                                                      1/0
 5008 FURMAT(lXoEllo402XoEllo4)
 6000 FORMAT(1H1.1X.16H THERE ARE (IS) .12.22H DATA DECK(S) PRESENT.)
                                                                      1/0
 6002 FORMAT (1H1.1X,14HTSTART
                                  = ,E13.6,23X,14HTSTOP
                                                             = .E13.6.I/O
                23X,14HDELTAT
                                  = ,E13.6)
                                                                      1/0
 6004 FORMAT (1X ) 14HALTITUDE
                              = ,E13.6)
                                                                      1/0
 6006 FURMAT(1X.6HTIBO1(.11.7H.1) = .F11.5,25X.6HTIBO1(.11.7H.2)
                                                                      1/0
     # Fll, 5, 25x, 6HT [BO] (, 11, 7H, 3) = , Fll, 5)
                                                                      1/0
                                                           ·E13.6 · 23X · 1/0
 6008 FURMAT(1X,14HWO(1)
                              m 9E13.6,23X.14HWO(2)
     •
                14HWO(3)
                              = ,E13.6)
                                                                      1/0
 6010 FORMAT (1X01HB+11012HMASS
                                   = 9E13.6)
                                                                      1/0
 6012 FURMAT(1x, 7HBODYOT(, 11, 6H, 1) = , E13, 6, 23x, 7HBODYOT(, 11, 6H, 2) =
                                                                      T/O
     $E&3.6.23X,7HBODYOI(,11.6H,3) = ,E13.6)
                                                                      1/0
 6014 FORMAT (1X+14HNUMCMG
                              s , [2)
                                                                      1/0
 6016 FURNAT (1x . 1) HCMG NUMBER . 11 . 21H IS A REACTION WHEEL.)
                                                                      I/O
 6018 FURMAT (1x, 11 HCMG NUMBER . II, 26H HAS ONE DEGREE OF FREEDOM)
                                                                      1/0
 6020 FURMAT(1X.11HCMG NUMBER , 11.27H HAS TWO DEGREES OF FREEDOM)
6022 FURMAT(1X.35HTHE ANGULAR MOMENTUM OF CMG NUMBER , 11,3H = ,E13.6)
                                                                      I/O
                                                                      I/O
 6024 FORMAT(1×05HAOCJ(01101H001106H01) # 0F1105025X05HAOCJ(01101H00110 1/0
```

1/0

# 6He2) = ef11.5925X95HAOCJ(9I191H99I1.6H93) = 9F11.5)

```
6026 FORMAT(1X+4HAII(+11+1H++11+7H+1) = +E13+6+23X+4HAII(+11+1H++11+
                                                                      1/0
    * 7H_{1} = .613.6.23X.4HAII(.11.1H.11.7H.3) = <math>.613.6
                                                                      1/0
6028 FORMAT(1X,6HTHATA(,11,7H) = ,E13.6,23X,7HTHATAD(,11,6H)
                                                                      1/0
    * £13.6)
                                                                      1/2
6030 FORMAT(1X+6HAIO(+11+1H++11+7H+1) = +E13.6+23X+4HAIO(+11+1H++11+
                                                                      1/0
    * 7_{H},2) = .613.6.23X.4HAIO(.11.1H..11.7H.3) = .613.6)
                                                                      1/0
6032 FORMAT (1X,4HFEE (,11,9H)
                               = ,E13.6,23X,5HFEED(,11.8H)
                                                                      1/0
    # £13.6)
                                                                      1/0
6040 FORMAY(1X97HBODY11(01106H01) = 0E1306023X07HBODY11(01106H02) = 0
                                                                      1/0
    * £13.6,23x,7HBQDY;I(,11,6H,3) * ,E13.6)
                                                                      1/0
6042 FORMAT (3X+34HTHETA) = ,E13.6,23X,14HOMEGA1
                                                         € .E13.6)
                                                                      1/0
6044 FURMAT(1X014HD01(1)
                             = 9E13.6+23X.14HD01(2)
                                                         = .E13.6.
                                                                      1/0
                             = .E13.6)
           23X,14HD01(3)
                                                                      1/0
6048 FORMAT(1X,14HD13(1)
                             = .E13.6,23X.14HD13(2)
                                                         = ,E13,6,
                                                                      1/0
                              = .E13.6)
                                                                      1/0
           23X • 14HD13(3)
6050 FORMAT(1X+14HD14(1)
                              = ,E13.6,23x,14HD14(2)
                                                         = .E13.6,
                                                                      1/0
           23×,14HD14(3)
                              = .E13.6)
                                                                      I/0
6052 FORMAT(1X+1HS+11+12H(1)
                                  # +E13.6+23X+1HS+11+12H(2)
                                                                   = +1/0
    #E13.6,23X,1H5,11912H(3)
                                   = +E13.6
                                                                      1/0
6058 FORMAT (1X , 14HPEND3L
                              = .E13.6)
                                                                      1/0
6060 FURMAT (1X) 16HTHETA3
                              = .E13.6)
                                                                      1/0
6002 FURMAT (1X , 14HOMEGA3
                              = ,E13.0)
                                                                      1/0
6064 FORMAT (1X , ) SHPENDAL
                              = eE13.61
                                                                      1/0
                              = ,E13.6,23X,14HOMEGA4
6066 FURMAT (1X+14HTHETA4
                                                        = ,E13.6
                                                                      1/0
6008 FURMAT (1X#14HIDOCK
                              = .12)
                                                                      1/0
6070 FORMAT (1X, 14HDTIME
                              = .E13.6)
                                                                      1/0
6072 FURMAT (1X+14HIPROPF
                              = .12)
                                                                      1/0
6074 FURMAT (1X,4HAOJ (,12,8H)
                                s ,E13,6,23X,7HCGAINO(,12,5H)
                                                                      1/0
    # E13.6)
                                                                      1/0
6076 FURMAT(1X,4HA1J(,11,9H)
                                # ,E13.6,23X,7HCGAIN1(,I1,6H)
                                                                      1/0
    # E13.6)
                                                                      1/0
6078 FORMAT (1X+14HIGRAVE
                              = .12
                                                                      1/0
6080 FORMAT (1X, 14HSP
                                                                      1/0
                              = .E13.6)
6082 FORMAT(1H1,1X,9HIPNDLM = ,12,/)
                                                                      1/0
6500 FORMAT (1H) .1X,46H THE FOLLOWING INPUT CORRESPONDS TO DATA DECK .121/0
    #)
*****
                                                                      1/0
6504 FURMAT (1X014HTIME
                              = .F11.5,/)
                                                                      1/0
6506 FORMAT(1X.1HW, 11.12H(1)
                                   # .E13.6.23X.1HW.11.12H(2)
                                                                     *I/0.
    4E13.6,23X.1HW.11.12H(3)
                                   = (E13.6)
                                                                      1/0
                              = ,E13.6,23x,14HH(2)
6510 FORMAT(1X+14HH(1)
                                                         ■ .E13.6,
                                                                      1/0
           23X 9 14HH(3)
                              = .E13.6)
                                                                      1/0
6512 FORMAT(1X014HHI(1)
                              = oE13.6+23X,14HHI(2)
                                                                      1/0
                                                         = ,E13.6,
           23X914HH1(3)
                              = .E13.6)
                                                                       1/0
6514 FORMAT(1X,14HHDOT(1)
                              = .E13.6,23X.14HHDOT(2)
                                                         = aE13.6.
                                                                      1/0
           23X • 14HHD0T(3)
                              = ,£13.6)
                                                                      1/0
6516 FORMAT(1X+1H+,11+12HPRIM(1)
                                   = .E13.6.23X.1HH.11.12HPRIM(2)
                                                                   = \cdot 1/0
    #E1346.23X.1HH, 11,12HPRIM(3)
                                   # #£13.6)
                                                                      1/0
6522 FORMAT(1X02HEL,11,11H(1)
                                   = +E13.6.23X.2HEL.II.11H(2)
                                                                     ·1/0
     #E13.6,23X,2HEL,11,11H(3)
                                   = (E13.6)
                                                                      1/0
 6524 FORMAT (1X, 2HEL, 11, 11HDOT (1)
                                   → +E13.6,23X,2HEL;11,11HD0<sup>T</sup>(2)
                                                                   = .I/O
     #El3.6.23X.2HEL.II.11HDOT(3)
                                   # +E13.6)
                                                                      1/0
6526 FORMAT(1X,1HR,11,12H(1)
                                  = ,E13.6,23X,1HR,11,12H(2)
                                                                   = ,1/0
     0E13.6,23X,1HR,11,12H(3)
                                   = +E13.6)
                                                                      1/0
 6528 FORMAT(1X+)HR+IJ+12HDOT(1)
                                   = ,E13,6,23X,1HR,I1,12HDOT(2)
                                                                   = •I/O
     #E13.6,23%,1HR,11,12MDOT(3)
                                   = ,E13.6)
                                                                       1/0
 6535 FOKMAY(1X,14HD12(1)
                              = .E13.6,23X,14HD12(2)
                                                         = .E13.6.
                                                                       1/0
           23X+14HD12(3)
                              = .E13.6)
                                                                       1/0
 6536 FORMAT (1X+14HTHETO
                             ■ .F11.5.25X,14HTOTMAS
                                                         = ,E13,6,/)
                                                                       1/0
 6538 FORMAT(1X,5HTIBO(,11,8H,1) # ,F11,5,25X,5HTIBO(,11,8H,2) = ,
                                                                       1/0
```

```
*F11.5,25X.5HTIBO(,11,8H.3)
                                                                                      # .F11.51
                                                                                                                                                                                 Ī/0
                                                                                 · [2)
  6544 FORMAT(IX)14HIPRINT
                                                                                                                                                                                 †/0
  6546 FURMAT (IX, 14HIB2F
                                                                                 ($1,
                                                                            $
                                                                                                                                                                                 1/0
  6548 FURMAT(IX,14HS
                                                                            # .E13.6.29x.14HSDO9
                                                                                                                                                 = ,E13,6}
                                                                                                                                                                                 1/0
  6550 FORMAT(LX-19HGENERAL INFORMATION:/)
                                                                                                                                                                                 1/0
  6552 FURMAT(IX. SHBODY , II. 12H INFORMATION, /)
                                                                                                                                                                                 1/0
  6554 FORMAT(/)
                                                                                                                                                                                 1/0
  6556 FORMATILX. IAHS
                                                                            # .E13.6.23X.16HSDOT
                                                                                                                                                 = .E13.6}
                                                                                                                                                                                 1/0
 6558 FURMATILX. SHTHETA, II. 8H
                                                                                      = +E13.6.23X.5HOMEGA.11.8H
                                                                                                                                                                                 1/0
            * E13.6)
                                                                                                                                                                                 Î/D
  6560 FOMMAT ( LX ) 1HG , I 1 0 12H
                                                                                                                                                                               . I/O
                                                                                        TOURSION OF THE PROPERTY OF TH
           * £13.6)
                                                                                                                                                                                 1/0
  6562 FORMAT (IX. 14HIATTIF
                                                                                 ·[1]
                                                                                                                                                                                 1/0
  6564 FORMAT(IX, 14HCA(1)
                                                                                 •E13.6,23X.14HCA(2)
                                                                                                                                                 = .E13.6.
                                                                                                                                                                                 1/0
                             23X+14HCA(3)
                                                                            #
                                                                                 oE13.6)
                                                                                                                                                                                 1/0
  6566 FORMAT ( IX , 14 HAAO )
                                                                                 ,E13,6,23x,14HAGAIN1
                                                                                                                                                  = .E13.6)
                                                                                                                                                                                 1/0
  6568 FORMAT ( | X, 14HAAO2
                                                                            = .213.6.23x,14HAGAIN2
                                                                                                                                                  = eE13.6)
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  6570 FURMAT (1X+14HNGAIN
                                                                            = .12)
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  6972 FURMAT(1X, SHGAIN(, 11,8H)
                                                                                      # .E13.6)
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  6574 FORMAT(1X,14HBDMASS
                                                                            = .El3.6)
                                                                                                                                                                                 1/0
  6576 FORMAT()X07HBODYDI(01106H01) B 0E1306,23X07HBODYDI(01106H02) B
                                                                                                                                                                                 1/0
            #E13.6,23x.7HBODYDI(,11,6H,3) = ,E13.6)
                                                                                                                                                                                 I/O
  6578 FORMAT (1X, 14HDTI(1)
                                                                            = 0.6023X.14HDTI(2)
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                             23X:14HDTI(3)
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  6580 FORMAY (1X, 20HDOCKING HAS OCCURRED)
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  6582 FORMAT(1X,14HCP1
                                                                            ≈ .E13.6)
                                                                                                                                                                                  1/0
  6584 FURMAT(1X+14HCP2
                                                                            = 0E33.6)
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  6586 FURMAY (1X. JAHDDO1 (1)
                                                                            = 0E13.6,23x,14HDD01(2)
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                             23X,14HDD01(3)
                                                                            # .E13.6)
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  6588 FORMAT (1X,54HTHE TOTAL PROPULSION IMPULSE ON THE TRANSVERSE AXIS =1/0
            ¢ ,E33,6)
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  6590 FORMAT (1X & 48HTHE TOTAL PROPULSION IMPULSE ON THE SPIN: AXIS = .
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SUBROUTINE ATT

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  COMMON
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  ATT
   ICFD # 0
                                                                         ATT
  IF (ICFA .EQ. 1) 60 TO 11
IF (ABS(WO[2]) .GT. 0.0002) GO TO 60
                                                                         ATT
                                                                         ATT
   IF (ASS(WO(3)) .GT. 0.0002) GO TO 60
                                                                        ĄŢŢ
  DO 10 Mml.3
                                                                         ATT
                                                                         ATT
  CB(M) = TIBO(1,M) *CA(1) + TIBO(2,M) *CA(2) + TIBO(3,M) *CA(3)
10 CONTINUE
                                                                         ATT
   IF (CB(1) .LT. 0.9994) GO TO 11
                                                                         ATT
                                                                         ÁTT
   ICEA = 0
  · ICFB = 0
                                                                         ATT
   ICFC # 0
                                                                         ATT
   GO TO 60
                                                                         ATT
11 CONTINUE
                                                                         ATT.
   ICFA = 1
                                                                         ATT
   IF (ICFB .EQ. 1) GO TO 30
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   TMA S. TIME
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   ZTCL 3 00
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   DU 13 N=1,3
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   T^{C}(M_{\bullet}N) = TIBO(M_{\bullet}N)
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13 CONTINUE
                                                                        ATT
   CN $ CB(3) $$2 + CB(2) *$2
                                                                        ATT
   CN # SORT (CN)
                                                                        ATT
   CAZ m CB(2)/CN
                                                                        ATT
   GA3 = CB(3)/CN
   AL # 0.50ACOS(CB(1))
                                                                        ATT
   AK a BODY11(1,1) #OMEGA1#SIN(AL)/(5.5 + DELTAT)
                                                                        ATT
   ICFB e 1
                                                                        ATT
30 CONTINUE
                                                                        ATT
   TMACHK = TMA + 5.0
                                                                        ATT
   IF (TIME .GT. THACHK) GO TO 40
                                                                        ATT
   ICFD # 1
                                                                        ATT
   60 TO 60
                                                                        ATT
40 CONTINUE
                                                                        ATT
   IF (ICFC .EQ. 1) GO TO 50
                                                                        ATT
   ZTC = -CA3+(TC(1,2)+TIBO(1,1)+TC(2,2)+TIBO(2,1)+TC(3,2)+TIBO(3,1))ATT
         +CA2*(TC(1*3)*T180(1*1)+TC(2*3)*T180(2*1)+TC(3*3)*T180(3*1))ATT
   IF (ZTC .GT. ZTCL) GO TO 71
                                                                        ATT
   ZTCL B ZTC
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   GU TO 60
                                                                        ATT
71 CONTINUE
                                                                        ATT
   TMB D: TIME
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   TMC = TMB = TMA = 6.0
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   TMC = TMB + TMC
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   TMB # TMC ♦ 5.0
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   ICFC g 1
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   GO TO 60
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50 CONTINUE
                                                                        ATT
   IF (TIME .GT. PMB) GO TO 80
                                                                        ATT
   IF (TIME .LT. TMC) GO TO 60
                                                                        APT
   ICFD a 1
                                                                        ATT
   GO TO 60
                                                                        ATT.
BO CONTINUE
                                                                        ATT
   ICFA B. O
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   ICFB s o
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   ICFC & O
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60 CONTINUE
                                                                        ATT
   IF (ICFD .EQ. 0) GO TO 90
                                                                        ATT
   1006(S) a vkacus
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   TWOP(3) 8 AK#CA3
                                                                        ATT
   FAT(1) @ 2.#ABS(TQ9P(2)/A0J(2))
                                                                        ATT
   FAT(2) \approx 2.0 ABS(TQQP(3)/AOJ(3))
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90 CONTINUE
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65 CONTINUE
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   RETURN
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SUBROUTINE CMG

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                                                                                                                         COMMC
                       R4ZCS
                                                                                              SINFEJ
                                                                                                                        COMMO
   COMMON
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                                                           SINTTO
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                                                                                               S3(3)
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                       EMU2
                                                           S2(3)
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                                                                                                                         COMMC
                       54(3)
                                                                                               TEMP1(3)
    COMMON
                                                                                                                         COMMC
                        T(3.3)
                                                           TC(393)
                                               ø
  4
                        TEMP2(3)
                                                                                                                         COMMO
                                               ø
                                                                                               TEMP5(3.3)
  #
                                                           TEMP4(3)
                                                                                                                         COMMC
                        TEMP3(3)
                                               •
  ø
                                                           TEMP7 (3.3)
                                                                                               TEMPS(3.3)
                                                                                                                         COMMC
                        TEMP6 (303)
                                               •
  ø
                                                                                               TEMP11(3,3)
                                                                                                                         COMMO
                        TEMP9 (3+3)
                                                           TEMP10(3,3)
                                               ø
                                                                                   Ð
                        TEMP12(3,3)
                                                           TEMP33(3,93)
                                                                                               TEMP14(303)
                                                                                                                         COMMC
                                               0
                                                                                                                         COMMC
  ۵
                                                                                               TERM2(3)
                        TEMP15 (3+3)
                                                           TERM& (3)
                                               9
  ø
                                                                                               THATAD (6)
                                                                                                                         COMMC
                                               9
                                                           THATA(6)
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                        THETAS
                                               9
                                                           EATBHT
                                                           TIB0(3,3)
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                                                           TJ
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                        TIME
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             3
                                                           TJ3(10)
                                                                                               TJ4(10)
                                                                                                                         COMMC
                        TJ2(10)
                        TMOTOR
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                                                            TOTMAS
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                                                                                                                         COMMC
                        TOEF (3)
                                                                                   9
                                                                                               T03G(3)
                        TQ0G-(3)
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                                                                                               TS70P
                        TG1P(3)
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                        T1EF(3)
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                        WO (3)
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    COMMON
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                                                                                                                          EOMMC
                                                            W4(3)
                        W3(3)
                                               9
                                                                                               XCDOT
    COMMON
                        X(6:7)
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   8
                        UMX
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     #
     *
     ୭୭୭୦% ପ୍ରକ୍ତ୍ର ପ୍ରକ୍ତିର ବ୍ରତ୍ତିକ ପ୍ରକ୍ତିକ ବ୍ରତ୍ତିକ ଅନ୍ତର୍ଭ କଳ୍ପ ବ୍ରତ୍ତିକ ଅନ୍ତର୍ଭ ବ୍ରତ୍ତିକ ଅନ୍ତର୍ଭ ବ୍ରତ୍ତିକ ଦେଉ କଳ୍ପ ବ୍ରତ୍ତିକ ଦେଉ ଦ୍ରତ୍ତିକ ଦ
                                                                                                                          CMG
                                                                                                                          CMG
    FFF(1) = 0.
                                                                                                                           СМG
     FFF-(2) = 0.
     FFF(3) = 0
                                                                                                                           CMG
     DO 5 Mml 03
                                                                                                                           CMG
     DO 5 Na1.3
                                                                                                                           CMG
     ESE(M.N) = 0.
                                                                                                                           CMG
 5 CONTINUE
                                                                                                                           CMG
     J. ** 0
                                                                                                                           CMG
10 June 1
                                                                                                                          CMG
     IFIU. . GT. NUMCHG) RETURN
                                                                                                                           CMG
     IF (IDOF (J) ONE. O) GO TO 20
                                                                                                                           CMG
     FFJ(1) = AOCJ(J,1,3)*HW(J)
                                                                                                                           CMG
     FFJ(2) = AOCJ(J,8,3)*HV(J)
                                                                                                                           CMG
     FFU(3) = AOCJ(Jo3o3) PHW(J)
                                                                                                                           CMG
     DO 15 M#1.3
                                                                                                                           CMG
     DO 15 N=193
                                                                                                                           CMG
     EEU(NIN) THE OP
                                                                                                                           CMG
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15 CONTINUE
                                                                         CMB
   60 TO 65
                                                                         CMG
20 IF(IDOF(J) .NE. 1) GO TO 35
                                                                         CMG
   SINTTU = SIN(THATA(J))
                                                                         CMG
   COSTTJ = COS(THATA(J))
                                                                         CMG
   SINFEJ = SIN(FEE(J))
                                                                         CMG
   CUSFEJ = COS(FEE(J))
                                                                         CMG
   TEMP12(1)
             # COSTTJ#AII(J+1+2)#THATAD(J)
                                                                         CMG
               LTTMICA(L)WH + (L)DATAHT*(S.E.L)IIA*LTTMIC+
                                                                         CMG
   TEMP12(2) = SINFEJ&SINTTJ#AII(J.1.2)#THATAD(J)
                                                                         CMG
               +COSFEJ#AII(J,2,2)#THATAD(J)
                                                                         CMG
               -SINFEJ#COSTTJ#AII(J,3,2)#THATAD(J)
                                                                         CMG
   TEMP12(3) #=SINTTJ#COSFEJ#ATT(J+1+2)#THATAD(J)
                                                                         CMG
               +SINFEJ#AII(J+2+2)#THATAD(j)
                                                                         CMG
               +COSFEJ*COSTTJ#AII(J,3,2)*THATAD(J) + HW(J)*COSTTJ
                                                                         CMG
   DO 22 Mm1.3
                                                                         CMG
   FFJ(M) = AOCJ(J_0M_01) + TEMP12(1) + AOCJ(J_0M_02) + TEMP12(2)
                                                                         CMG
           +AOCJ(J.M.3) *TEMP12(3)
                                                                         CMG
22. CONTINUE
                                                                         CMG
   TEMP13(101) = COSTIJ#AOCJ(J0101) + SINFEJ#SINTTJ#AOCJ(J0102)
                                                                         CMG
                 -SINTTJ#COSFEJ#AOCJ(J,1,3)
                                                                         CMG
   TEMP13(1:2) = COSTTJ#AOCJ(J:2:1) + SINFEJ#SINTTJ#AOCJ(J:2:2)
                                                                         CMG
                 -SINTIJ#COSFEJ#A0CU(J+Z+3)
                                                                         CMG
   TEMP13(1.3)
               # COSTTJ#AOCJ(J.3.1) + SINFEJ#SINTTJ#AOCJ(J.3.2)
                                                                         CMG
                 -SINTTJ#COSFEJ#AOCJ(J+3+3)
                                                                         CMG
   TEMP13(201)
                = COSFEJ#AOCJ(J.1.2) + SINFEJ#AOCJ(J.1.3)
                                                                         CMG
   TEMP13 (2,2)
                = COSFEJ#AOCJ(J.2.2) + SINFEJ#AOCJ(J.2.3)
                                                                         CMG
                = COSFEJ#AOCJ(J.3.2)
   TEMP13(203)
                                        SINFEU#AOCU(J+3+3)
                                                                         CMG
   TEMP13(3:1)
                # SINTTJ#AOCJ(J:1:1) = SINFEJ#COSTTJ#AOCJ(J:1:2)
                                                                         CMG
                 +COSFEJ#COSTTJ#AOCJ(J,1,3)
                                                                         CMG
   TEMP13(3+2)
               = SINTTJAOCJ(J.2.1) = SINFEJ*COSTTJ*AOCJ(J.2.2)
                                                                         CMG.
                 +COSPEU#COSTTU#A0CJ(J,2,3)
                                                                         CMG
   TEMP13(3.3)
                # SINTTJ#AOCJ(J.3.1) = SINFEJ#COSTTJ#AOCJ(J.3.2)
                                                                         CMG
                 +COSFEJ4COSTTJ4AOCJ(J.3.3)
                                                                         CMG
   DO 25 M=1.3
                                                                         CMG
   DO 25 N=1.3
                                                                         CMG
   TEMP14(M+N) = AII(J+M+1)+TEMP13(1+N)
                                          + AII(J.M.2) #TEMP13(2.N)
                                                                         CMG
                 (N.E) EIGMBT*(E.M.L) IIA+
                                                                         CMG
25 CONTINUE
                                                                         CMG
   TEMP15(1+1) #
                   COSTTJ#TEMP14(1+1) + SINTTJ#TEMP14(3+1)
                                                                         CMG
   TEMP15(102)
                   COSTTJ&TEMP14(1.2)
                                       + SINTTJ#TEMP14(3.2)
                                                                         CMG
   TEMP15 (1.03)
                   COSTTJ#TEMP14(1.3) + SINTTJ#TEMP14(3.3)
                                                                         CMG
                   SINFEJ#SINTTJ#TEMP14(1,1) + COSFEJ#TEMP14(2.1)
   TEMP15(2:1)
                                                                         CMG
                  -SINFEJ+COSTTJ+TEMP14(3.1)
                                                                         CMG
   TEMP15(2.2)
                   SINFEJ#SINTTJ#TEMP14(1.2) + COSFEJ#TEMP14(2.2)
                                                                         CMG
                  -SINFEJ@COSTTJ@TEMP14(3.2)
                                                                         CMG
   TEMP15(203) = SINFEJ#SINTTJ#TEMP14(1,3)
                                               + COSFEJOTEMP14(2+3)
                                                                         CMG
                  -SINFEJ#COSTTJ#TEMP14(3:3)
                                                                         CMG
   TEMP15(3:1)
               = -SINTTJ#COSFEJ#TEMP14(1,1)
                                               + SINFEJATEMP14(201)
                                                                         CMG
                  +GOSFEJ#COSTTJ#TEMP14(3,1)
                                                                         CMG
                  -SINTTJ+COSFEJ#TEMP14(1,2)
   TEMP15(3,2)
                                                SINREJATEMP14(2,2)
                                                                         CMG
                  +COSFEJ#COSTTJ#TEMP14(3,2)
                                                                         CMG
   TEMP15.(3+3)
               = =SINTTJ#COSFEJ#TEMP14(1,3)
                                               + SINFEJATEMP14(2+3)
                                                                         CMG
                  ocosfej#costtj#TemP14(3.3)
                                                                         CMG
   DO 30 Mal+3
                                                                         CMG
   00 30 N=1.3
                                                                         CMG
   EEU(M.N) = AOCJ(J.M.1) +TEMP15(1.N) + AOCJ(J.M.2) +TEMP15(2.N)
                                                                         CMG
              +AOCJ(J.M.3) @TEMP15(3,N)
                                                                         CMG
30 CONTINUE
                                                                         CMG
   GO TO: 60
                                                                         CMG
35 CONTINUE
                                                                         CMG
   SINTTJ = SIN(THATA(J))
                                                                         CMG
```

```
COSTTJ = COS(THATA(J))
                                                                          CMG
  SINFEJ = SIN(FEE(J))
                                                                          ČMG
  COSFEL = COS(FEE(J))
                                                                          CMG
  IEMP1(1) = AIO(Jolol) &FEED(J)
                                                                          CMG
  TEMPI(2) a COSFEJWAIO(J.2.1) #FEED(J) - SINFEJ#AIO(J.3.1) #FEED(J)
                                                                          CMG
  TEMP1(3) = SINFEJOAIO(Jo201) OFEED(J) + COSFEJOAIO(J.301) OFEED(J)
                                                                          CMG
  TEMP2(1) =COSTTJ#(AII(J.1.1) +COSTTJ#FEED(J)+AII(J.1.2) +THATAD(J)+
                                                                          CMG
 + AII(J,1,3) ASINTTJOFEED(J))+SINTTJO(AII(J,3,1)OCOSTTJOFEED(J)+
                                                                          CMG
  AII (Jo302) OTHATAD (J) +AII (J,303) #SINTTJ #FEED (J))
                                                                          CMG
  +(L) D337WFEJ SINTIJA (A.I.) IIA) & LTTINIZ& L37WFEZ (2) S4W3T
                                                                          CMG
 * All(Jolo2) OTHATAD(J) AARI(Jolo3) &SINTTJ OFEED(J)) *
                                                                          CMG
 # GOSFEJ# (ATT (J.2.1) #COSTTJ#FEED (J) ATT (J.2.2) #THATAD (J) .
                                                                          CMG
 * AII(Jo2+3) OSINTTJOFEED(J))-
                                                                          CMG
 # SINFEJOCOSTTJO(AII(JoBol) OCOSTTJOFEED (J) +AII(JoBo2) OTHATAD(J) +
                                                                          CMG
 # AII(Jo3o3) OSINTTJOFEED(J))
                                                                          CMG
  TEMP2(3) ==SINTTJOCOSPEJ*(AII(Jolo1) COSTTJ*FEED(J)+
                                                                          CMG
 * AII(J.1.2) THATAD(J) AAII(J,1.03) *SINTTJ*FEED(J)) *
                                                                          CMG
 SINFEJ*(AÎÎ(J.2.1)*COSTTJ*FEED(J)*AÎÎ(J.2.2)*THĂTAD(J)*
                                                                          CMG
 ALL (Joz+3) OSINTTJOFEED (J))+
                                                                          CMG
 # COSPEJOCOSTTJO (ALI (J.3.1) *COSTTJOFEEN (J) +AII (J.3.2) #THATAD (J) +
                                                                          CMG
 * AII(Jo3o3)@SINTTJ@FEED(J))
                                                                          CMG
               LTTNIZ (L) WH
  TEMP3(1) &
                                                                          CMG
  TEMP3(2) & -HW(J) OCOSTIJOSINFEJ
                                                                          CMG
               HW (J) & COSTTJ & COSFEJ
  TEMP3(3) =
                                                                          CMG
   TEMP4(1) \Rightarrow TEMP1(1) + TEMP2(1) + TEMP3(1)
                                                                          CMG
   TEMP4(2) = TEMP1(2) + TEMP2(2) + TEMP3(2)
                                                                          CMG
   TEMP6(3) \square TEMP1(3) + TEMP2(3) + TEMP3(3)
                                                                          CMG
   FFJ(1) = AOCJ(Jolol) #TEMP4(1)
                                                                          CMG
           $AOCJ(J,1,2) #7EMP4(2) + AOCJ(J,1,3) #7EMP4(3)
                                                                          CMG
   FFJ(2) = AOCJ(Jo203) OTEMP4(1)
                                                                          CMG
           $AOCJ(J;2;2)$TEMP4(2) $ AOCJ(J;2;3)$TEMP4(3)
                                                                          CMG
   FFJ(3) = A00J(J_03_01) \circ TEMP4(1)
                                                                          CMG
           +ADCJ(J03,2) ATEMP4(2) + AOCJ(J,3,3) ATEMP4(3)
                                                                          CMG
   TEMP5(1.1) =
                  . (£, £, £, LOOA
                                                                          CMG
   TEMP5(1.2) =
                  (6050F) LOOA
                                                                           CMG
   TEMPS(1.3) =
                  AOCJ (Jogo))
                                                                          CMG
   TEMP5 (2:01) a
                  COSFEUDAOCJ(J.1.2) + SINFEJ#AOCJ(J.1.3)
                                                                          CMG
   TEMP8(2.2) .s
                  COSFEJOAOCJ(J.2.2)
                                         SINFEJ#AOCJ (J+2.3)
                                                                          CMG
   TEMP5(2.3)
                  COSFEJ#AOCJ(J+3+2)
              23
                                         SINFEJOAOCJ(Jo3.3)
                                                                          ÇMG
   TEMP5 (3.1)
                 -SINFEJ#AOCJ(J.1.2)
                                       COCFEJPAOCJ(Jele3)
                                                                          CMG
   TEMP5 (3.2) 3
                -SINFEU#AOCJ(J.2.2) + COSFEJ#AOCJ(J.2.3)
                                                                           CMG
   TEMPS(3.3) s -SINFEJOAOCJ(J.3.2) + COSFEJOAOCJ(J.3.3)
                                                                           CMG
   DO 00 Mml 03
                                                                           CMG
   DO 40 Nole3
                                                                          CMG
   TEMP6(MoN) & ARO(JOMO)) #TEMP5(1.N) + AIO(J.M.2) #TEMP5(2.N)
                                                                           CMG
  Ö
                AATO (JoMo 3) OTEMP5 (3.N)
                                                                           CMG
40 CONTINUE
                                                                           CMG
   TEMP7(1.01) B
                  TEMP6(101)
                                                                           CMG
   TEMP7(1.2) a
                  TEMP6(1.2)
                                                                           CMG
  - TEMP7(1.3) :2
                  TEMP6 (1,3)
                                                                           CMG
                  COSPEJOTEMP6(2.1) - SINFEJOTEMP6(3.1)
   TEMP7(201) =
                                                                           ČMG
   TEMP7(202) .a
                  COSFEJATEMP6 (2+2) - SINFEJATEMP6 (3+2)
                                                                           CMG
                  COSPEUDTEMP6(2,3) - SINEEJ-TEMP6(3;3)
   TEMP7(2,3) 8
                                                                           CMG
   TEMP7(301) 10
                  sinfejotempo(2.1) + cosfejotempo(3,1)
                                                                           CMG
                  SINFEUPTEMP6(2.2) + COSFEJ#TEMP6(3:2)
   TEMP7 (302) 0
                                                                           CMG
   TEMP7(3,3)
                  SINFEJOTEMP6(2.3) + COSFEJOTEMP6(3.3)
                                                                           CMG
   TEMP8(1.1) =
                 COSTTJ#ACCJ(J.1.1) + SINFEJ#SINTTJ#ACCJ(J.1.2)
                                                                           CMG
                "SINTTJOCOSFEJOAOCJ(J.1.3)
                                                                           CMG
   TEMP8(1,2) = COSTT-JACCJ(Jo2,1) . O. SINFEJASINTT-JACCJ(J.2,2)
                                                                           CMG
                -SINTTJ#COSFEJ#AOCJ(J.2.3)
                                                                           CMG
   TEMP8(1,3) = COSTTJ=AOCJ(J,3,1) + SINFEJ+SINTTJ+AOCJ(J,3,2)
                                                                           CMG
                -SINTTJ#COSFEJ#AOCJ(J.3.3)
                                                                           CMG
```

```
CMG
      TEMP8(2.1) = cosfej#AOCJ(J:1:2) + SINFEJ#AOCJ(J:1:3)
      TEMP8(2,2) = cosfej*Aocj(j,2,2) + sinfej*Aocj(j,2,3)
                                                                                                                                                  CMG
      TEMP8(2,3) = COSEEJ#AOCJ(J,3,2) + SINFEJ#AOCJ(J,3,3)
                                                                                                                                                  CMG
      TEMP8(3,1) = Sinttu#Aocu(J.1.1) = Sinfeu#Costtu#Aocu(J.1.2)
                                                                                                                                                  CMG
                               +COSFEJ*COSTTJ*AOCJ(J0103)
                                                                                                                                                  CMG
      TEMP8 (3,2)
                             * SINTTJ#AOCJ(J,2,1) = SINFEJ#COSTTJ#AOCJ(J,2,2)
                                                                                                                                                  CMG
                               +COSFEJ#COSTTJ#AOCJ(J+2+3)
                                                                                                                                                  CMG
      TEMP8(3.3) = SINTTJ#AOCJ(J.3.1) - SINFEJ#COSTTJ#AOCJ(J.3.2)
                                                                                                                                                  CMG
                                +COSFEJ*COSTTJ$ADCJ(J.3.3)
                                                                                                                                                  CMG
     DO 45 Mm1.3
                                                                                                                                                  CMG
      DO 45 N=1.3
                                                                                                                                                  CMG
      (N_{\bullet}S) and (N_{\bullet}S) and (N_{\bullet}S) and (N_{\bullet}S) are the solution of the state of the st
                                                                                                                                                  CMG
                                +AII(J+M+3)#TEMP8(3+N)
                                                                                                                                                  CMG
45 CONTINUE
                                                                                                                                                   CMG
                               = COSTTJ*TEMP9(1.1) \diamond SINTTJ*TEMP9(3.1)
      TEMP10(1+1)
                                                                                                                                                   CMG
      TEMP10(1,2)
                               \pm COSTTJ#TEMP9(1.2) + SINTTJ#TEMP9(3.2)
                                                                                                                                                   CMG
                               # COSTTJ#TEMP9(1.3) + SINTTJ#TEMP9(3.3)
      TEMP10(1+3)
                                                                                                                                                   CMG
                               # SINFEJ#SINTTJ#TEMP#(1+1) + COSFEJ#TEMP9(2+1)
      TEMP10(2,1)
                                                                                                                                                   CMG
                                  -SINFEJOCOSYYJ&YEMP9(301)
                                                                                                                                                   CMG
      TEMP10(2.2) = SINFEJOSINTTJOTEMP9(1.2) + COSFEJOTEMP9(2.2)
                                                                                                                                                   CMG.
                                  -SINFEJ&COSTTJ&TEMP9(302)
                                                                                                                                                   CMB
      TEMP10(2+3) = SINFEJ#SINTTJ4TEMP9(1+3)
                                                                                         CHG
                                  -SINFEJ#COSTTJ#TEMP9(3+3)
                                                                                                                                                   CMG
                                                                                         + SINFEJATEMP9(2.1)
      TEMP10(3+1)
                               #=SINTTJ#COSFEJ#TEMP9(1:1)
                                                                                                                                                   CMG
                                  +COSFEJ#COSTTJ#TEMP9(3+1)
                                                                                                                                                   CMG
      TEMP10(3+2) ==SINTTJ#COSFEJ#TEMP9(1+2)
                                                                                         . SINFEJATEMP9(2.2)
                                                                                                                                                   CMG.
                                  +COSFEJ*COSTTJ*TEMP9(3.2)
                                                                                                                                                   CMG
      TEMP10(3.3) ##SINTTJ#COSFEJ#TEMP9(1.3)
                                                                                         + SINFEJATEMP9(2.3)
                                                                                                                                                   CMG
                                  COSFEJ#COSTTJ#TEMP9(303)
                                                                                                                                                   CMG.
      DO 50 Mml.3
                                                                                                                                                   CMG
      DO 50 Nml.3
                                                                                                                                                   CMG.
      TEMPli(M \cdot N) = TEMP7(M \cdot N) + TEMPlo(M \cdot N)
                                                                                                                                                   CMG
50 CONTINUE
                                                                                                                                                   CMG
      DO 55 Mml.3
                                                                                                                                                   CMG
      DO 55 Nal+3
                                                                                                                                                   CMG
      EEJ(M.N) # AOCJ(J.M.) #TEMP11(1.N) + AOCJ(J.M.2) #TEMP11(2.N)
                                                                                                                                                   CMG
                            +AOCJ(J.M.) STEMP11(3,N)
                                                                                                                                                   ČMG
55 CONTINUE
                                                                                                                                                   CMG
OO THATA(J) = THATA(J) + THATAD(J) DELTAT
                                                                                                                                                   CMG
      FEE(J) = FEE(J) + FEED(J) *DELTAT
                                                                                                                                                   CMG
65 CONTINUE
                                                                                                                                                   CMG
      DO 70 M=1.3
                                                                                                                                                   CMG
      FFF(M) = FFF(M) + FFJ(M)
                                                                                                                                                   CMG
70 CONTINUE
                                                                                                                                                   CMG
      DO 75 M=1.3
                                                                                                                                                   CMG
      DO 75 N=1.3
                                                                                                                                                   CMG
       EEE(M.N) = EEE(M.N) + EEJ(M.N)
                                                                                                                                                   CMG
75 CONTINUE
                                                                                                                                                   CMG
      GO 70 10
                                                                                                                                                   CMG
                                                                                                                                                   CMG
      ₩٠
       ö,
       #• 1
      END
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CCCC

C

SUBROUTINE EMCALC

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ବଳ୍ପଳ ପ୍ରତ୍ୟକ୍ତ ପ୍ରତ୍ର୍ୟ ପ୍ରତ୍ର୍ୟ ପର୍ବ୍ୟ କ୍ଷ୍ୟ କ୍ଷ୍ୟ କ୍ଷ୍ୟ କ୍ଷ୍ୟ ବ୍ୟବର ବ୍ୟ
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                          A (3)
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                          AFOUR (2)
                                                                     AII (6,3,3)
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                                                                     (E) ILA
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                          (E,E,0)01A
                                                                                                                 ALT
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                          A0CJ(6,3,3)
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ď
                          ATCPTE(303)
                                                                     ATHREE (5)
                                                                                                                 ATHO(4)
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Ö
                          A1 (3,3)
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  COMMON
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                          BODYD1 (3,3)
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                                                                                                                 BTHREE (5)
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                                                                     BONE (7)
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Ø
                                                                     BIMASS
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                          BTWO (4)
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                                                                      B4MASS
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  COMMON
                                                                      CB (3)
                                                                                                                 CGAINO(3)
                          CA (3)
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                          CGAIN1(2)
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                                                       9
  COMMON
                          OB (3)
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Ø
                          DELTAT
                                                                      DO1 (3)
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6
                          (E) ITG
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4
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                          DTIME
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                          Dl3DQT(3)
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                          D14DOT(3)
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                          D14ZGS
                                                                      D14ZSN
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  COMMON
                                                                      EEJ (3,3)
                          EEE (303)
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                          ELZDOT (3)
                                                                      EL2YCS
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                          EL3001(3)
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                           EL3ZCS
                                                                      EL3ZSN
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                                                                      ELAYCS
                          EL4DOT(3)
                                                                                                                 ELAYSN
                                                                                                                                                  COMMO
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                           el4zcs
                                                                      ELGZSN
                                                                                                                 EM(6,6)
                                                                                                                                                  COMMC
  COMMON
                           FAT(8)
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8
                                                                      FEED (6)
                           FEE (6)
                                                                                                                  FFF (3)
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#
                           REJ(3)
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                           FO(3)
                                                                      FO1(3)
                                                                                                                  P02(3)
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 4
                           F03(3)
                                                                      F3 (3)
                                                                                                                  F11(3)
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 ٥
                           FPT(S)
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                           F12(3)
                                                                      F13(3)
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  COMMON
                                                                      GЗ
                           GAIN(10)
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                           03D01
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   COMMON
                                                                      HCMG (3)
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                                                                                                                  HDOT (3)
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 45
                           HT (3)
                                                                      HQ(3)
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 ₩
                                                                      HIPDOT(3)
                          M1(3)
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                           H3PRIM(3)
                                                                      H4PRIM(3)
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   COMMON
                           182F
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                                                                       ICED
                           ICFC
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                           100F(6)
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                           IGRAVE
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                                                                                                                  IPNTCK
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                           IPRINT
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   COMMON
                                                                      NCHECK
                           NCASE
                                                                                                                  NDECK
                                                                                                                                                  COMMO
                           NGAIN
                                                                      NUMCMG
                                                                                                                                                   COMMO
   COMMON
                           OMEGA!
                                                                      OMEGA3
                                                                                                                  OMEGA4
                                                                                                                                                   COMMO
   COMMON
                           PENDIL
                                                                      PEND4L
                                                                                                                                                   COMMO
   COMMON
                           Q (4 , 4)
                                                                                                                                                   COMMO
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COMMC
COMMON
                               ..R0(3)
                                                     R1431
                         9
                                                                     COMME
           R1007(5)
                                RIYCS
                                                     RIÝSN
                                                                     COMMO
                                RIZSN
                                                     R2:(3)
           RIZCS
           R2DOT(3)
                                R2YCS
                                                     RZYSN
                                                                     COMMC
                                                     R3(3)
                                R2ZSN
                                                                     COMMC
           -R2ZCS
                                RBYCS
                                                     RBYSN
           R3DOT(3)
                                                                     COMMC
                                                     R4(3)
           R3ZČS
                                R3ZSN
                                                                     COMMC
                                R4YCS
                                                     R4YSN
           R4DOT(3)
                                                                     COMMO
           R4ZCS
                                R4ZSN
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                                                     SINFEJ
COMMON
                                SDOT
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                                                     SINTT
           SINTTJ
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           SÎNTÎZ
SP
                                SINTT3
                                                     SINTT4
                                                                     COMMO
                                                     SUM2
                                ŠÜMI
                                                                     COMMC
                                52(3)
                                                     S3(3)
           SUM3
                                                                     COMMC
           S4(3)
                                                                     COMMC
COMMON
                                . TC (3+3)
                                                     TEMP1 (3)
                                                                     COMMC
            T(3.3)
            TEMP2(3)
                                                                     COMMC
                                TEMP4 (3)
                                                     TEMP5 (3.3)
                                                                     COMMC
            Temp3(3)
                                 TEMP? (3,3)
                                                      TEMP8 (3,3)
            TEMP6 (3,3)
                                                                     COMMC
            TEMP9 (3,3)
                                 TEMP10(3,3)
                                                      TEMP11(3+3)
                                                                     COMMC
            TEMP12(3.3)
                                                      TEMP14(3,3)
                                 TEMP13(3,3)
                                                                     COMMC
            TEMP15(3,3)
                                 TERMI(3)
                                                      TERM2(3)
                                                                     COMMC
                                                      THATAD(6)
            TFRICT
                                 THATA(6)
                                                                     COMMC
                                                      THETA
                                 THE TA3
            THETA1
                                                                     COMMC
                                                                     COMMC
                                 TIB0(3,3)
            THETO
                                                      TIBOI (3.3)
                                 TJ
                                                      TJ1(10)
                                                                     COMMO
            TIME
                         9
                                 TJ3(10)
            TJ2(10)
                                                      TJ4(10)
                                                                     COMMO
            TMOTOR
                                                                     COMMC
                                 TOTMAS
                                                                     COMMC
            TOEF (3)
                                                      T01
                                 TQOP (3)
                                                      TQ16(3)
            TQOG(3)
                                                                     COMMO
                                                      TSTOP
                                 TSTART
            TQ1P-(3)
                                                                     COMMC
                                 TTOOT
            TTIDOT
                                                      TT4DOT
                         •
                                                                     COMMC
            T1EF(3)
                                 T13
                                                      T14
                                                                     COMMC
COMMON
                                                                     COMMC
            V (3)
                                 WS
COMMON
                                                      W1(3)
            MO(3)
                                                                     COMMC
                                 W4-(3)
            W3 (3)
                                                                     COMMC
                                 χC
COMMON
            X (6,7)
                                                      XCDOT
                                                                     COMMC
            XMU
                                                                     COMMC
₩.
#
EMCAL
THE FOLLOWING CALCULATIONS WILL BE USED REPEATEDLY TO CALCULATE M EMCAL
                                                                     EMCAL
SINTT1 = SIN(THETAL)
                                                                     EMCAL
COSTT1 = COS(THETA1)
                                                                     EMCAL
CO2T = COSTT1##2
                                                                     EMCAL
CST # COSTTI#SINTTI
                                                                     EMCAL
SI2T = SINTT1##2
                                                                     EMCAL
RIYGS # R1(2) #COSTT1
                                                                     EMCAL
RZYCS = RZ(2) *COSTT1
                                                                     EMCAL
R3YCS # R3(2) #C05TT1
                                                                     EMCAL
RAYCS = R4(2) *COSTT1
                                                                     EMCAL
RIZCS # R1(3)*COSTT1
                                                                     EMCAL
RZZCS # RZ(3)*COSTT1
                                                                     EMCAL
R3ZCS = R3(3)*COSTT1
                                                                     EMCAL
R4ZCs = R4(3)*CostTl
                                                                     EMCAL
R1Y5N .m. R1(2) #$INTT1
                                                                     EMCAL
R2YSN = R2(2) *SINTT1
                                                                     EMCAL
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R3YSN = R3(2)*SINTT1
                                                                               EMCAL
     R4YSN = R4(2) *SINTTL
                                                                               EMCAL
      RIZSN = RI(3)*SINTT1
                                                                               EMCAL
      R22SN = R2(3)*SINTII
                                                                               EMCAL
      RJZSN = RJ(3)*SINT[1
                                                                               EMCAL
      R^4ZSN = R^4(3)*SINTT1
                                                                               EMCAL
      ELZYCS = ELZ(2) #COSTT1
                                                                               EMCAL
      EL3YCS = EL3(2) #COSTT1
                                                                               EMCAL.
      LLAYCS = EL4(2) #COSTT1
                                                                               EMCAL
      ELZZCS = ELZ(3) #COSTT1
                                                                               EMCAL
                                                                             · EMÇAL
      EL3ZCS = EL3(3)#COSTT1
      EL4ZCS = EL4(3)*COST11
                                                                               EMCAL
      EL2YSN = EL2(2) *SINTT1
                                                                               EMCAL
      EL3YSN = EL3(2) #SINTT1
                                                                               EMCAL
      EL4YSN = EL4(2) #SINTT1
                                                                               EMCAL
      EL2ZSN = EL2(3) *SINTT1
                                                                               EMCAL
      EL3ZSN = EL3(3) &SINTT1
                                                                               EMCAL
      EL4ZSN = EL4(3) #SINTT]
                                                                               EMCAL
      D13YCS = D13(2) *COSTT1
                                                                               EMCAL
      D14YCS = D14(2) #C0STT1
                                                                               EMCAL
      D13ZCS = D13(3) *CoSTT_{1}
                                                                               EMCAL
      D14ZCS = D14(3) *COSTT1
                                                                               EMCAL
      D13YSN = D13(2) *SINTT1
                                                                               EMCAL
      D14YSN = D14(2) *SINTT1
                                                                               EMCAL
      D13ZSN = D13(3) \Rightarrow SINTT1
                                                                               EMCAL
      D14ZSN = D14(3) + SINTT1
                                                                               EMCAL
      MMOM=BOMASS/TOTMAS
                                                                               EMCAL
      EM(1+1)=BODYOI(1+1)+BODYII(1+1)+B1MASS*DO1(2)*(R1YCS*R1ZSN)+
                                                                               EMCAL
     * BIMASS*DO1(3) + (RIYSN+RIZCS) +B2MASS* (R2YCS-R2ZSN) + (DO1(2)+EL2YCS+ EMCAL
     * LLZZSN) +B2MASS* (R2YSN+R2ZCS) * (D01(3) +ELZYSN+ELZZCS) +B3MASS* (R3YCSEMCAL
* -R3ZSN) * (D01(2) +D13YCS-D13ZSN+EL3YCS-EL3ZSN) +B3MASS* (R3YSN+R3ZCS) EMCAL
     * *(DO1(3)*D13YSN*D13ZC5+EL3YSN+EL3ZCS) +B4MASS*(R4YCS+R4ZSN) *
                                                                               EMCAL
      (DO1(2)+D14YCS-D14ZSN+EL4YCS-EL4ZSN)+B4MASS*(R4YSN+R4ZCS)+
                                                                               EMCAL
     * (DO1(3)+D14YSN+D14ZCS+EL4YSN+EL4ZCS)
                                                                               EMCAL
C
                                                                               EMCAL
      EM(1.2)=BODYOI(1.2)+BODYII(1.2)*COST1-BODYII(1.3)*SINTT1
                                                                               EMCAL
              -B1MASS#R1(1) #D01(2) #
                                                                               EMCAL
     * WZMASS*R2(1)*(D01(2)+EL2YCS-EL2ZSN)-
                                                                               EMCAL
     * #3MASS*R3(1)*(D01(2)+D13YCS+D13ZSN+E[3YCS+EL3ZSN)+
                                                                               EMCAL
     * #4MASS*R4(1)*(DOI(2)+D14YCS=D14ZSN+E14YCS=EL4ZSN)
                                                                               EMCAL
                                                                               EMCAL
C
      EM(1+3)=BODYOI(1+3)+BODYII(1+2)*SINTT1+BODYII(1+3)*COSTT1
                                                                               EMCAL
              -81MASS#R1(1)#D01(3)-
                                                                               EMCAL
     * #2MASS#R2(1) * (DO1(3).+EL2YSN+EL2ZCS) -
                                                                               EMCAL
       #3MASS*R3(1)*(D01(3)+D13YSN+D13ZCS+EL3YSN+EL3ZCS)+
                                                                               EMCAL
     * b4MASS*R4(1)*(D01(3)+D14YSN+D14ZCS+E_4YSN+EL4ZCS)
                                                                               EMCAL
¢
                                                                               EMCAL
      Em(1+4)=B0DY1I(1+1)=B1MASS*D01(3)*(BMOM*D01(3)=R1YSN=R1ZCS)+
                                                                               EMCAL
     * BIMASS*DO1(2)*(R1YCS=R1ZSN=BMOM*DO1(2))=
                                                                               EMCAL
     * BZMASS* (DO1(3) +EL2YSN+EL2ZCS) *(BMOM*DO1(3) -R2YSN-R2ZCS) +
                                                                               EMCAL
     * b2MASS*(001(2) +EL2YCS-EL2ZSN) *(R2YCS-R2ZSN-BMOM*D01(2)) -
                                                                               EMCAL
     * B3MASS*(D01(3)+(013(2)+EL3(2))*SINTT1+(D13(3)+EL3(3))*COSTT1)*
                                                                               EMCAL

# (BMOM*DO1(3)=R3YSN=R3ZCS)+
                                                                               EMCAL
     # #3MASS*(D01(2)+(D13(2)+EL3(2))*COSTT1=(D13(3)+EL3(3))*SINTT1)*
                                                                               EMCAL
     * (R3YCS-R3ZSN-BMOM*DO)(2))-
                                                                               EMCAL
     * B4MASS*(DO1(3)+(D14(2)+EL4(2))*SINTT1+(D14(3)+EL4(3))*COSTT1)*
                                                                                EMCAL
     * (BMOM*DO1(3)-R4YSN-R4ZCS)+
                                                                                EMCAL
     * G4MASS*(D01(2) + (D14(2) +EL4(2)) +COSTT1=(D14(3) +EL4(3)) +SINTT1) +
                                                                                EMCAL
     * (R4YCS-X4ZSN-BMOM#D01(2))
                                                                                EMCAL
C
                                                                                EMCAL
      Em(1,5)==B3MASS#R3(3)+($3(3)+EL3(1)+S3(1)+EL3(3))+
                                                                                EMCAL
     * B3MASS*R3(2)*(-S3(2)*EL3(1)*S3(1)*EL3(2)) -
                                                                                EMCAL
```

```
C
                                                                             Ε
      Em(1+6)=-84MASS*R4(3)*($4(3)*EL4(1)=$4(1)*EL4(3))+
     * b4MASS*R4(2)*(=54(2)*EL4(1)+54(1)*EL4(2))
                                                                             E
C
      EM(2,1)=BODYOI(2,1)+BODYII(2,1)*COSTT1-BODYII(3,1)*SINTY1-
     * BIMASS&DO1(1) * (R1YCS=R1ZSN) -
                                                                             Ę
     * b2MASS*(R2YCS=R2ZSN)*(D01(1)+EL2(1))=
                                                                             E
     * B3MASS* (R3YCS-R3ZSN) * (D01(1) +D13(1) +EL3(1)) -
                                                                             E
     * B4MASS*(R4YCS=R4ZSN)*(D01(1)*D14(1)+FL4(1))
                                                                             E
C
      EM(2.2) =BODYOI(2.2) +BODYII(2.2) *CO2T =BODYII(2.3) *CST
                                                                             Ε
     * -BODY11(3,2)*CST + BODY11(3,3)*SI2T +
     * blmass*R1(1)*D01(1)*Blmass*D01(3)*(R1YSN+R1ZCS)*
                                                                             Ε
     * B2MASS#R2(1)*(D01(1)+EL2(1))+
     * B2MASS* (H2YSN+R2ZCS) * (D01 (3) +EL2YSN+EL2ZCS) +
      * #3MASS*R3(1)*(D01(1)+D13(1)+EL3(1))+
     * B3MASS*(R3YSN+R3ZCS)*(D01(3)+D13YSN+D13ZCS+EL3YSN+ELBZCS)+
     * B4MASS&R4(2)*(D01(1)+D14(1) &EL4(1))+
     * B4MASS* (R4YSN+R4ZCS) * (D01(3) +D14YSN+D14ZCS+EL4YSN+EL4ZCS)
C
      EM(2,3) =80DY01(2,3) +80DY11(2,2) +CST +B0DY11(2,3) +C02T
     * -BODY11(3,2) #SI2T - BODY11(3,3) #CST -
     * BIMASS*UOI(3) * (RIYCS=RIZSN) =
     * B2MASS* (R2YCS-R2ZSN) * (D01(3) +EL2YSN+EL2ZCS) +
     * B3MASS*(R3YCS-R3ZSN)*(D01(3)*D13YSN+D13ZCS+EL3YSN+EL3ZCS)-
     # #4MASS#(R4YCS=R4ZSN)#(D01(3)+D14YSN+D14ZCS+EL4Y5N+EL4ZCS)
C.
      EM(2,4)=BODY11(1,2)*COSTT1-BODY11(1,3)*SINTT1-BIMASS*DO1(1)*R1YCS+F
     * BlmAss*DO1(1)*R1ZSN+BMOM*B1MASS*DO1(1)*DO1(2)=
     * B2MASS*(D01(1)+EL2(1))*(R2YCS-R2ZSN-RMOM*D01(2))-
     * B3MASS*(U01(1)+013(1)+EL3(1))*(R3YCS_R3ZSN-BMOM*D01(2))-
     # d4mAss*(D01(1)+D14(1)+EL4(1))#(R4YCs_R4ZsN-BMOM#D01(2))
C
      EM(2+5) = (B3MASS*R3(3) * (*S3(3) *EL3(2) +93(2) *EL3(3)) +
     * B3MASS*H3(1)*(=$3(2)*EL3(1)+$3(1)*EL3(2)))*COSTT1-
     * (+B3MASS*R3(2)*(-$3(3)*EL3(2)+53(2)*FL3(3))+
     * B3MASS*R3(1)*($3(3)*EL3(1)*S3(1)*EL3(3)))*S[NTT]
С
      EM(2,6)=(B4MASS*R4(3)+(-54(3)*EL4(2)+54(2)*EL4(3))-
     * 54MASS*R4(1)*(-S4(2)*EL4(1)*S4(1)*EL4(2)))*COSTT1+
     * (-B4MASS*R4(2)*(=S4(3)*EL4(2)+S4(2)*EL4(3))+
     * B4MASS*R4(1)*(S4(3)*EL4(1)-S4(1)*EL4(3)))*SINTT1
C
      EM(3+1)=BODYOI(3+1)+BODY1I(2+1)+SINTT1+BODY1I(3+1)+COSTT1=
     # D]MASS*DOL(1) * (R1YSN+R1ZCS) -
     * B2MASS*(D01(1)+EL2(1))*(R2YSN+R2ZCS)-
     * B3MASS*(D01(1)+D13(1)+EL3(1))*(R3YSN+R3ZCS)=
     * B4MASS*(D01(1)+D14(1)+EL4(1))*(R4YSN+R4ZCS)
C
      EM(3,2)=BODYOI(3,2)+BODY1I(2,2)*CST -BODY1I(2,3)*SIZT
     * +B00Y11(3,2) *C02T-B0DY11(3,3) *C5T-
     * BlMASS*DO1(2) * (R1YSN+R1ZCS) .
     * BZMASS* (HZYSN+RZZCS) * (DO1(2) +ELZYCS-ELZZSN) - B3MASS* (R3YSN+RZZCS) * (DO1(2) +D13YCS-D13ZSN+EL3YCS-ELZZSN) -
     * H4MASS*(R4YSN+R4ZCS)*(D01(2)+D14YCS-D14ZSN+EL4YCS-EL4ZSN)
C
      LM(3,3)=BODYOI(3,3)+BODYII(2,2)*SIZT +BODYII(2,3)*CST
     * +B00Y11(3,2)*CST + B00Y11(3,3)*C02T +
     * blmass*R1(1)*D01(1)*H1MASS*(R1YCS=R17SN)*D01(2)*
* BZMASS*R2(1)*(D01(1)*EL2(1))*
     # BZMASS# (H2YCS_R2ZSN) # (D01(2) +EL2YCS-FL2ZSN) +
     * b3MASS*R3(1)*(D01(1)+D13(1)+EL3(1))+
```

```
* B3MASS+(R3YCS-R3ZSN)+(D01(2)+D13YCS-613ZSN+EL3YCS-EL3ZSN)+
                                                                             EMCAL
                                                                             EMCAL
     * HAMASSOR4(1) * (DO) (1) *D16(1) *EL4(1) ) *
     * BAMASS* (RAYCS-RAZSN) & (DO) (2) +D14YCS-D14ZSN+EL4YCS-EL4ZSN)
                                                                             EMCAL
                                                                             EMCAL
C.
      EM(304)=BODY11(102) #SINTT1+BODY11(103) #COSTT10
                                                                             ENCAL
     # BlmAss*DO1(1)*(BMOM*DO1(3)*R1YSN*R1ZCS)*
                                                                             EMCAL
     * BZMASS+(DOI(1)+ELZ(1))+(BMOM+DOI(3)-RZYSN-RZZCS)+
                                                                             EMCAL
     * B3MASS* (DO1(1) D13(1) EL3(1)) * (BMOMODO1(3) -R3YSN-R3ZCS) *
                                                                             EMCAL
     * BAMASS* (DO] (1) +D] 4(1) +EL4(1)) * (BMOM*DO] (3) -R4YSN-R4ZCS)
                                                                             EMCAL
C
                                                                             EMCAL
      EM(3.5): (B3MASSOR3(3)0(-63(3)0EL3(2)-53(2)0EL3(3))-
                                                                             EMCAL
     * bimass+R3(1) + (-53(2) +EL3(1)+53(1) +EL3(2)) +S1NTT1+
                                                                             EMCAL
     # (@B3MASSOR3(2)0(053(3)0EL3(2)053(2)0EL3(3))0
                                                                             EMCAL
     # B3MASS#R3(1) # (S3(3) PEL3(1) -S3(1) PEL3(3))) #COSTT1
                                                                             EMCAL
C
                                                                             EMCAL
      EM (3,6) :: (84MASGOR4 (3) & (054 (3) &EL4(2)+54 (2) &EL4(3)) 0
                                                                             EMCAL
     * BAMASS.. R4(1) # (-54(2) OEL4(1) +54(1) #EL4(2))) #51NTTlo
                                                                             EMCAL
     * (-B4MASS*R4(2) 4 (-S4(3) *EL4(2) +S4(2) *EL4(3)) +
                                                                             EMCAL
     # #4MASS*R4(3) * (S4(3) *EL4(1) -S4(3) *EL4(3))) *COSTT1
                                                                             EMCAL
CCC
                                                                             EMCAL
      NOW SET UP THE LOWER HALF OF THE M MATRIX.
                                                                              EMCAL
                                                                              EMCAL
      DEFINE SOME REOCCURRING TERMS
                                                                              EMCAL
      SR3 = B.3MASS&(D]3(2) & EL3(2))
                                                                              EMCAL
      584 a B3MASSa(D13(3) & EL3(3))
                                                                              EMCAL
      SRS \alpha BAMASSA(D]A(2) + ELA(2))
                                                                              EMCAL
      SR6 # B4MAS$#(D]$(3) + EL4(3))
                                                                              EMCAL
      SR1=BODY 11 (1,2)-B2MASSOEL2 (2)-0R2(1)-SR3&R3(1)-SR5&R4(1)
                                                                              EMCAL
      $R2=BODY||1(1,3)||-B2MA$$*&L2(3)|*R2(1)|-$R4*R3(1)|-$R4*R4(1)|
                                                                              EMCAL
C
                                                                              EMCAL
      EM(4+1)=BODY11(101) &BZMASS&(ELZ(3) &RZ(3) &ELZ(2) &RZ(2)) &
                                                                              EMCAL
     * SR40R3(3) + SR30R3(2) + SR60R4(3) + SR50R4(2)
                                                                              EMCAL
                                                                              EMCAL
C
      EM(402) =SR10COSTT1 =SR20SINTT1
                                                                              ENCAL
Ĉ:
                                                                              EMCAL
      EM(4.3) =SR1@SINTT1 &SR2@COSTT1
                                                                              EMCAL
C
                                                                              EMÇAL
      REDEFINE SRI AND SRZ
                                                                              EMCAL
      SR1#8MOM# (DO1 (2) #COSTT1+DO1 (3) #SINTT1)
                                                                              EMCAL
      SR2DBMOMP (-DO](2) PSINTT1 DO](3) *COSTT1)
                                                                              EMCAL
C
                                                                              EMCAL
      EM(404) = BODY18(101)
                                                                              EMCAL
                +B2MASSO(EL2(3) + (R2(3) - SR2) + EL2(2) + (R2(2) - SR1)) +
                                                                              ENCAL
     * SR60(R3(3)-SR2)0SR30(R3(2)-SR1)0SR60(R4(3)-SR2)0SR50(R4(2)-SR1)
¢
      EM(4,5) =83MASS&(((R3(3)-SR2)OEL3(3)+(R3(2)-SR1)-EL3(2))+S3(1)-
     * (R3(2) -SR1) &EL3(1) &S3(2) - (R3(3) -SR2) &EL3(1) &S3(3))
C
       0 (R4(2)=5R1) &EL4(1) &54(2) = (R4(3) =5R2) &EL4(1) &54(3)
C
       EM (501) =-B3MASSAEL3(1) & (R3(2) &S3(2) &R3(3) &S3(3))
Ç٠
       EM (502) =B3MASSO(((EL3(3) PR3(3) OEL3(1) OR3(1)) OCOSTTIO
      * EL3:(3) #R3YSN) #S3(2) * (=EL3(2) #R3ZCS* (EL3(2) #R3(2) *EL3(1) #R3(1) #
      # SINTT1) #$3(3))
Ç
       EM(5,3) 283MASS&(((EL3(3) 4R3(3) &EL3(1) 6R3(1)) &SINTTIO
      * EL3(3) @R3YCS) @S3(2) + (-EL3(2) @R3ZSN+(EL3(2) @R3(2) +EL3(1) #R3(1) #
      * COSTT1) $53(3))
C
       EM(5,6) =B3MASSOEL3(1)+0((-R3(2)+SR1)+S3(2)+(-R3(3)+SR2)+S3(3))
```

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'C':
      EM(5,5)=B3MASS+(1,=B3MASS/TOTMAS)+(((EL3(3)+42+EL3(1)++2)+S3(2)=
                                                                         EMCAL
     • EL3(3) +EL3(2) +S3(3)) +S3(2) + ((EL3(2) +62+EL3(1) ++2) +S3(3) =
                                                                         EMCAL
     * EL3(2) *EL3(3) *S3(2)) *S3(3))
                                                                         FMCAL
                                                                         FRCA
Ĉ٠
      EM (5,6) = (B3MASS+B4MASS/TOTMAS) + ( (= (EL3(3) +EL4(3) +EL3(1) +EL4(1) ) +
                                                                         EMCAL
     # $4(2)+EL3(3)#EL4(2)#$4(3))#$3(2)+(=(EL3(2)#EL4(2)+ELB(1)#EL4(1))#EMCAL
     * S4(3) +EL3(2) +EL4(3) +S4(2)) +S3(3))
                                                                         EMCAL
C
                                                                         EMCAL
      EM (6 - 1) = -BAMASS+EL4 (1) + (R4 (2) +S4 (2) +R4 (3) +S4 (3) )
                                                                         EMCAL
                                                                         EMCAL
      EM (6+2) =B4MASS+ (((EL4(3)*R4(3)+EL4(1)+R4(1))+COSTTI+EL4(3)*R4YSN) *EMCAL
     * S4(2) * (*EL4(2) *R4ZCS=(EL4(2) *R4(2) *EL4(1) *R4(1) **SINTT1) *S4(3))
                                                                         EMCAL
                                                                         EMCAL
C
      EM (6+3) #B4MASS+ (((EL4(3)*R4(3)+EL4(1)*R4(1)) #SINTT1-EL4(3)*R4YCS) #EMCAL
     # 54(2) + (=EL4(2) +R4ZSN+ (EL4(2) +R4(2) +E[4(1) +R4(1)) +COSTT1) +S4(3))
                                                                         EMCAL
                                                                         EMCAL.
C
      EM(6+4) mB4MASS#EL4(1)*((=R4(2)+SR1)*S4(2)+(-R4(3)*SR2)*S4(3))
                                                                         EMCAL
C
                                                                         EMCAL
      EM (6,5) = (83MASS&B&MASS/TOTMAS) & ( (= (EL4(3) *EL3(3) *EL4(1) *EL3(1)) *
                                                                         EMCAL
     * S3(3)+EL4(2)#EL3(3)#S3(2))#S4(3))
                                                                         EMCAL
                                                                         ENCAL
C
      EM (6.6) = B4MASS# (1. = B4MASS/TOTMAS) + ( (FL4(3) + #2 + EL4(1) + #2) + S4(2) =
                                                                         EMCAL
     # EL4(3)#EL4(2)#S4(3))#S4(2)#((EL4(2)##2+EL4(1)##2)#S4(3)#
                                                                         EMCAL
     # EL4(2) #EL4(3) #S4(2)) #S4(3)}
                                                                         EMCAL
      DO 10 M=1.3
                                                                         EMCAL
      DO 10 Nal.3
                                                                         EMCAL
      EM (MoN) DEM (MON) O EEE (MON)
                                                                         EMCAL
  10
      CONTINUE
                                                                         EMCAL
      RETURN
                                                                         EMCAL
CCCC
                                                                         EMCAL
      C
      4
```

END

#-END

```
SUBROUTINE FOMS (A.B.N.E.T.J)
 DIMENSION \Delta(1) \circ B(1) \circ TJ(1)
 FOMS
  A(1) CONTAINS THE CURRENT TIME. I.E.
                                                          FOYS
                                   A(1) = TIME.
  A(2) THROUGH A(N) CONTAIN THE INTEGRAL'S WHERE N EQUALS THE
                                                          FOMS
  NUMBER OF INTEGRALS PLUS 1.
                                                          FOMS
  TJ IS A SCRATCH ARRAY. TJ(1) CONTAINS THE INITIAL DELT AND TJ(2) EOMS THROUGH TJ(N) CONTAIN THE BACK VALUES OF THE DERIVATIVES. FOMS
  B(1) CONTAINS THE CURRENT DELT AND B(2) THROUGH B(N) CONTAIN THE
                                                          FOMS
  CURRENT DERIVATIVES.
                                                          FOM5
  IF E 0 000 REINITIALIZE THE DERIVATIVES.
                                                          FOMS
                                                          FOMS
  IF & B 1.0. CONTINUE THE INTEGRATION.
                                                          FOMS
  *
  #1
  FOMS
                                                          FOMS
  IF (N .LE. 1) RETURN
                                                          FOMS
  IF(E .NE. 0.) GO TO 20
  E 8. 1.
                                                          FOMS
  00 10 Imlon
                                                          FOMS
  TJ(1) = B(1)
                                                          FOMS
10 CONTINUE
                                                          FOMS
20 HO2 = 8(1) $0.5
                                                          FOMS
                                                          FOMS
  00 30 I=20N
  A(I) =: A(I) & HO29(309B(I)-TJ(I))
                                                          FOMS
  TJ(I) = B(I)
                                                          FOMS
30 CONTINUE
                                                          FOMS
                                                          FOMS
  A(1) \alpha A(1) \phi B(1)
                                                          FOMS
  RETURN
                                                          FOMS
  #
```

SUBROUTINE GGRAD

### CUMMON A(3) AE (5) AED(5) COMMC AII (6,3,3) COMMC AFOUR(2) • A10(6,3,3) (E) [LA ALT COMMC AONE (7) (E) LOA AOCJ(6.3:3) COMMC ATHREE (5) ATWO(4) ATCPT2(3:3) COMMC A1 (3,3) (2) LIA COMMO , COMMON BDMASS BFOUR (2) MOMB COMMC • B00Y11(3+3) BODYOI (3,3) BODYDI (3+3) COMMC • Ġ. BONE (7) BTHREE (5) BOMASS COMMO \* **B2MASS** BTWO(4) BIMASS COMMC 84MASS SZAMES COMMC 0 COMMON CB (3) CGAINO (3) COMMC CA (3) 0 ٠ CGAIN1 (2) COMMO COSTIJ COSTTO COSFEJ COMMC COSTI3 COMMC COSTTI COSTT4 Φ COST CP1 CP2 COMMC COMMC Cl COMMON 08:(3) DD01(3) COMMO • 001(3) DELTAT D01D0T(3) COMMC DTI (3) COMMC 9 ø COMMC DTIME D12(3) D13(3) 9 D13D0T(3) D13YCs D13YSN COMMO 9 D13ZCS D1325N D14(3) COMMC , 4 D14D0T(3) D14YCS DIAYSN COMMC D14ZCS D14ZSN COMMC COMMON EEE (3,3) EEJ(3,3) COMMC EL2(3) EL2DOT(3) ELZYCS EL2YSN COMMC , 4 EL2ZCS ELZZSN ELB(3) • COMMC EL300T(3) **EL3YCS** ELBYSN • COMMC ELBZCS **EL3ZSN** COMMO • EL4(3) 4 EL4DOT(3) EL4YCS ELAYSN COMMO **ELAZSN** EL4ZCS EM(6.6) • COMMC COMMON FAT(8) COMMC FEE (6) FEED (6) FFF (3) COMMC , FFJ(3) FLAGI FLAG2 COMMO , FLAG4 FLAG3 FNI COMMC , FO1(3) FO(3) F02(3) COMMC . F03(3) F1(3) F11(3) 9 COMMO FPT (5) COMMC F12(3) F13(3) COMMC COMMON GAIN(10) GЗ Ŷ COMMC G4 G3DOT **G4DOT** , COMMC COMMON HCMG (3) H(3) HDOT (3) 9 COMMC HI (3) (E) OH H# (6) COMMC. H1 (3) HIPDOT (3) HIPRIM(3) COMMC H3PRIM(3) HAPRIM(3) COMMC COMMON IB2F -ICFA ÍCFB COMMC . ICFC ICFD IDOCK COMMC IDOF(6) COMMC ø **IPNDLM IGRAVF IPNTCK** COMMC IPRINT IPROPF COMMO COMMON NCASE NCHECK NDECK COMMO NGAIN NUMCMG COMMC COMMON OMEGAL OMEGA3 OMEGA4 COMMC COMMON PEND3L PEND4L COMMC. COMMON Q(4,4) COMMC

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    #
    ø
     GGRAI
    SINTTO = SIN(THETO)
                                                                                                                      GGRAI
    CUSTTO = COS(THETO)
                                                                                                                      GGRA[
                                                 + COSTTOSTIBO(2,1)
    DB(1) = -SINTTOPTIBO(101)
                                                                                                                      GGRAC
                                                 + COSTTON [180 (2.2)
    DB(2) a -SINTTOATIBO(1.2)
                                                                                                                      GGRAF

    COSTTO©TIBO(2,3)

    OB(3) & -SINTTOATIBO(1.3)
                                                                                                                      GGRAI
    REMP a 0.
                                                                                                                      GGRAC
    DO 10 Mml 93
                                                                                                                      GGRAI
    REMP & REMP + DB (M) PRO (M)
                                                                                                                      GGRAL
10 CONTINUE
                                                                                                                      GGRA!
    00 20 L=1.3
                                                                                                                      GGRAL
     FOI(L) = CIOBOMASSO(3. OREMPODE(L) = RO(L))
                                                                                                                      GGRAL
     A(L) = 0.
                                                                                                                      GGRAF
     DO 20 M=1.3
                                                                                                                      GGRA[
     A(L) = A(L) + BODYOJ (L+M) DB(M)
                                                                                                                      GERAL
30
    CONTINUE
                                                                                                                      GGRAI
     1000(1) = 3.0010(08(2)0A(3) = 08(3)0A(2))
                                                                                                                      GGRAC
     TGOG(2) = 3.0C(06(3)0A(1) - DB(1)0A(3))
                                                                                                                      GGRAS
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R0 (34

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GGRAC
  TQOG(3) = 3.4C14(DB(1)+A(2) = DB(2)*A(1))
  DB(1) # "SINTTO"TIBO(1:1) + COSTTO"[180(2:1)
                                                                      GGRAC
  DB(2) # COSTT1+(=SINTTO+TIBO(1.2) + COSTTO+TIBO(2.2)) +
                                                                      GGRAC
           SINTT1*(*SINTTO*TIBO(1.3) + COSTTO*TIBO(2.3))
                                                                      GGRAC
  DB(3) ==SINTT1+(=SINTTO+TIBO(1+2) + COSTTO+TIBO(2+2)) +
                                                                      GGRAC
           COSTT1#(#SINTTO#T180(1+3) + COSTTO#T180(2+3))
                                                                      GGRAE
                                                                      GGRAF
  REMP # 0.
                                                                      GGRAE
  DO 30 Mal+3.
                                                                      GGRAE
  REMP # REMP + DB(M) #R1(M)
30 CONTINUE
                                                                      GGRAC
                                                                      GGRAC
   DO 40 L=1.3
   F11(L) = C1+B1MASS+(3.+REMP+DB(L) - RT(L))
                                                                      GGRAE
                                                                      GGRAC
   A(L) # 0.
                                                                      GGRAL
   DO 40 M=1.3
   A(L) # A(L) + BODYII(L,M)+DB(M)
                                                                      GGRA[
40 CONTINUE
                                                                      GGRAE
                                                                      GGRAE
   TQ1G(1) = 3.9C1*(DB(2)*A(3) = DB(3)*A(2))
   TQ1G(2) = 3.\%C1\%(DB(3)\%A(1) = DB(1)\%A(3))
TQ1G(3) = 3.\%C1\%(DB(1)\%A(2) = DB(2)\%A(1))
                                                                      GGRAE
                                                                      GGRA[
                                                                      GGRAL
   RETURN
                                                                      GGRA[
   4
   #
   4
   END
```

00000

SUBROUTINE HOON

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# #						
ጥ <b>ቁቀቁል</b> የተዋናው	<b>.</b> ტტტტტტტტტტტტტ	计分分分数	****	>#####	******************	****
COMMON	A(3)		AE (5)	•	AED (5)	• COMMC
o o jeji roste	AFOUR (2)	9	AII (6,3,3)	•		COMMC
	A10(603:3)	•	AJ1(3)	•	ALIT	• COMMC
	A0CU(6,3,3)	, e	A0J(3)	•	AONE (7)	• COMMC
	ATCPT2(3,3)	•	ATHREE (5)	•	ATWO (4)	. COMMC
	A1(3 <sub>9</sub> 3)		A1J(2)	,	7. <b>(</b>	COMMC
COMMON	BDMASS	•	BFOUR (2)	•	BMOM	• COMMC
AAMILOIA	80DYD1 (3+3)	•	BODY01(3,3)	•	BODY11(3,3)	• COMMC
•	BOMASS	9	BONE (7)	•	BTHREE (5)	o COMMC
	BTWO(4)	9	B1MASS	•	BZMASS	9 COMMC
•		•	BAMASS	•	95,1430	COMMC
COMMON	B3MASS	<del>9</del>	CB (3)	_	CGAINO(3)	COWNC
COMMON	CA(3)	9	CD(3)	7	CONTINOTS	-
	CGAIN1(2)	•	COCTT		CACTTA	COMMC
/ <b>-</b>	Cosfej	9	COSTIJ	•	COSTTO COSTT4	• COMMC
, •	COSTTI	•	COSTT3	•	C <sub>b</sub> S	• COMMC
;	COST.	•	c <sup>p</sup> 1	9	CF &	• COMMC
	CST	9	Cl CDC1/C			COMMC
COMMON	DB (3)	•	0001(3)	•		COMMC
•	DELTAT	•	DOJ (3)	•	D01D0 <sup>T</sup> (3)	• COMMC
•	011(3)	9			- 4 3 4 3 4	COMMC
<b>P</b> :	DTIME	7	012(3)	9 1	D13(3)	● ©OMMC
•	013001(3)	9	D13YCS	•	DIBARN	• ÇOMMC
•	0132C5	9	DIBZSN	•	014(3)	• COMMC
<b>*</b>	01400T(3)	9	D14YCS	•	D14YSN	• COMMC
<b>*</b>	D14ZCS	. 9	D14ZSN		_	ÇOMMC
COMMON	EEE (393)	•	EEJ(3•3)	•	EF5(3)	. COMMC
<b>,</b>	EL2007(3)	•	ELZYCS	•	EL2YSN	• COMMC
•	EL2ZC\$	•	EL2ZSN	•	ELG(3)	P COMMC
<b>\$</b>	EL3DOT(3)	•	EL3YCS	•	ELBYSN	• COMMC
<b>7</b>	EL3ZCS	9	el3Z\$n	9	EL# (3)	O COMMC
₩.	eladot (3)	•	EL4YCS	9	elaysn	• ÇOMMC
₽	EL4ZC5	9	EL4Z\$N	•	EMI(6,6)	COMMC
COMMON	FAT (8)	9				COMMC
<b>#</b>	PEE (6)	•	FEED (6)	P	FFF (3)	• COMMC
<del>*</del>	FFJ(3)	9	FLAG1	•	FLAG2	• COMMC
#	FLAG3	. 9	FLAG4	•	FNI	» ČOMMC
# &	FO(3)	9	FO1 (3)	•	F02(3)	9 COMMC
*	F03(3)	9	F1(3)	,	F11(3)	• COMMO
♦	FPT (5)	9				COMMO
<b>*</b>	F12(3)	•	F13(3)			COMMO
COMMON	GAIN(10)	9	Ġ <b>3</b>	•		COMMO
8	. 9300g	9	G4	•	GADOT	ÇOMMC
COMMON	H(3)	9	HCMG (3)	•	HDOT (3)	• COMMO
*	HI (3)	•	HO (3)	•	HWI(6)	9 COMMO
<b>.</b>	H3 (3)	9	HIPDOT(3)	9	HIPRÍM(3)	9 COMMO
*	H3PRÍM(3)	•	H4PRIM(3)	•	THE THE THE	COMMO
COMMON	1826	•	ICFA	9	icfb.	• COMMO
# with the latest and	icfç	9	įčfô	,	IDOCK	• COMMO
*	100F (6)	9	\$ <del>~</del> ; <del>~</del>	•	7 - A - 14	COMMO
*	IGRAVF	_	IPNOLM	•	IPNTCK	
•	IGRAY! IPRINT	<b>9</b>	IPROPF	•	Tention	9 ÇOMM( COMM(
СОММОН		37	NCHECK	ā	NDECK	
COMMON	NCASE	7		•	MARCH	• COMMO
▼ ' *	NGAIN	9	NUMCMG			COMM

END

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SUBROUTINE MULT (C, A, B, F, D, E, MTYPE)
CCCC
       *
       Ç
                                                                                     MULT
       DIMENSION
                    A(3,3)
                                           8(3)
                                                                   C(3)
                                   9
                                                                                   O MULT
                                                           0
                    D(3,3)
                                                                   F(303)
                                           E (303)
                                   0
                                                                                     MULT
C
                                                                                     MULT
       IF (MTYPE .NE. 1) GO TO 100
                                                                                     MULT
       C(1) a A(1,1) aB(1) + A(1,2) aB(2) + A(1,2) aB(3)
                                                                                     MULT
       C(2) * A(201) *B(1) * A(202) *B(2) * A(203) *B(3)
                                                                                     MULT
       C(3) 0 A(3,1) 0B(1) 0 A(3,2) 0B(2) 0 A(3,3) 0B(3)
                                                                                     MULT
       RETURN
                                                                                     MULT
  100 CONTINUE
                                                                                     MULT
       F(1 \circ 1) = D(1 \circ 1) \circ E(1 \circ 1) + D(1 \circ 2) \circ E(2 \circ 1) + D(1 \circ 3) \circ E(3 \circ 1)
                                                                                     MULT
       F(1.2) = D(1.1) $\mathbb{E}(1.2) + D(1.2) $\mathbb{E}(2.2) + D(1.3) $\mathbb{E}(3.2)$
                                                                                     MULY
       F(103) = D(101) \Phi E(103) + D(102) \Phi E(203) + D(103) \Phi E(303)
                                                                                     MULI
       F(201) = D(201) \Phi (101) + D(202) \Phi (201) + D(203) \Phi (301)
                                                                                     MULT
       f(2.2) = D(2.1) \Leftrightarrow E(1.2) \Leftrightarrow D(2.2) \Leftrightarrow D(2.3) \Leftrightarrow E(3.2)
                                                                                     MULT
       F(2.3) = D(2.1) $E(1.3) + D(2.2) $E(2.3) + D(2.3) $E(3.3)
                                                                                     MULT
       F(311) = D(301) 9E(201) + D(302) 4E(201) + D(303) 4E(301)
                                                                                     MULT
       F(3.2) = D(3.1) PE(1.2) + D(3.2) PE(2.2) + D(3.3) PE(3.2)
                                                                                     MULT
       F(3.3) = D(3.1) \Leftrightarrow E(1.3) \Leftrightarrow D(3.2) \Leftrightarrow E(2.3) \Leftrightarrow D(3.3) \Leftrightarrow E(3.3)
                                                                                     MULT
       RETURN
                                                                                     MULT
CCCC
                                                                                     MULT
       ₩.
       ₩
C.
       ¥
       END
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SUBROUTINE PCON

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****	****	***	****	. 5 5 4 5 1	*******	. 44. 45.1	
COMMON	A(3)	•	AE (5)	•	AED (5)	•	COMMC
•	AFOUR(2)	•	AII (6,3,3)	•	_		COMMC
*	A10(6:3:3)	•	V71 (3)	,	aliī	•	COMMC
₩	AOCJ (6,3,3)	•	AQJ (3)	•	AONE (7)	•	ÇOMMC
*	ATCPT2(3,3)	7	ATHREE (5)	•	ATWO(4)	•	COMMC
100	A1 (3,3)	9	41J(2)				COMMC
COMMON	BDMASS	•	BFOUR(2)	•	ВМОМ	•	COMMC
*	BODYDI (3,3)	•	BODYOT (3.3)	•	BODY11(3,3)	•	COMMC
2	BOMASS	•	BONE (7)	•	BTHREE (5)	•	ÇOMMC
•	STWO(4)	7	BIMASS	•	BZMASS	•	COMMC
COMMON	B3MASS	•	84MASS				COMMC
P COMMON	ÇA (3)	7	CB (3)	•	CGAINO(3)	,	COMMC
<b>\$</b>	CGAIN1(2) Cosfej	9	COSTT				COMMC
•	COSTTI	9	COSTŢJ COSŢ3	9	COSTTO	,	COMMC
<b>ú</b>	COSTI	9	CP1	•	ÇOSTT4	•	COMMC
•	CST	•	C1	•	CPZ	•	COMMC
COMMON	DB (3).	•	0001(3)	_			COMMC
*	DELTAT	•	001(3)	•	D01D0T(3)		COMMC
· <b>*</b>	DTI(3)	,	0.1(5)	7	0.100, (2)	,	COMMC
<b>∯</b>	DTIME	å	D12(3)	_	D13(3)	_	COMMC
*	D1300T(3)	í	DIBYČS	7	DIBYSN	,	COMMC
<b>#</b> •	DISZCS	ģ	DIBZSN	7	D14(3)	,	COMMC
•	D14DOT (3)	9	DIAYCS	•	DIAYSN		COMMC
*	D14ZCS	•	D1425N	•	D# 113/1	•	COMMC
COMMON	EEE(3+3)	•	EEJ(3,3)	•	ELE (3)		COMMC
₩	EL2007(3)	•	EL2YCS	•	ELZYSN		COMMC
*	ELZZCS	•	ELZZSN	•	ELG (3)	·	COMMC
<b>#</b>	EL3007(3)	9	EL3YCS	•	ELBYSN	•	COMMC
. <b>♥</b> .	EL3ZCS	9	EL3ZSN	•	EL# (3)	•	COMMC
₩,	EL4DOT(3)	•	EL4YCS	•	ELAYSN	•	COMMC
*	EL4ZCS	8	EL4ZSN	•	EM(6,6)	•	COMMC
COMMON	FAT(8)	•					COMMC
*	FEE (6)	9	FEED(6)	*	FFF(3)	•	COMMC
•	FFJ(3)	9	FLAGI	9	FLAG2	•	COMMC
<b>♥</b>	FLAG3	•	FLAG4	•	FNI	•	COMMC
<b>*</b>	FO(3)	•	FQ1(3)	,	F02(3)	•	COMMC
₩.	F03(3)	•	F1(3)	•	F11(3)	•	COMMC
₩ #	FPT(5)	9	ma = i = .				COMMC
COMMON	F12(3)	•	F13(3)				COMMC
COMMON	GAIN(10)	9	63	•	=		COMMC
COMMON	@3D07	•	G4	9	G4DOT		COMMC
e-	H(3)	V	HCMG(3)	•	HDOT (3)	•	COMMC
* .	HI(3) H1(3)	•	H0(3) H1PDOT <sub>(3)</sub>	•	HW'(6)	•	COMMC
<b></b>	H3PRIM(3)	•		7	HIPRIM(3)	•	(ÇOMMC
COMMON	IBSE:	9	H4PRIM(3) IGFA		i.aan		COMMC
A.	ICFC	•	ICFD	•	I CFB	•	COMMC
· <b>\$</b>	ÎDOF(6)	7	1010	•	IDOCK	,	COMMC
<b>#</b> -	IGRAVE	•	IPNDLM	_	SALIBAL		COMMC
<b>*</b> -	IPRINT	•	IPROPF	7	IPNTCK	•	- 1116
COMMON	NCASE	•	NCHECK	_	MDECH	_	COMMC
4	NGAIN	,	NUMCMG	•	NDECK	•	2 0 11.17
COMMON	OMEGA1	•	OMEGA3		OMEGA4		COMMC
COMMON	PEND3L	9	PEND4L	9	UMSUMT		COMMC
COMMON	Q(4,4)	•	i teri∓ta/⊤ţ <sub>er</sub>				COMMC
- · · · ·	= +		•				COMMC

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RQ(3)
                                                                                                         R1 (3)
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   COMMON
                         R
                                                                                                         RIYSN
                         RIDOT(3)
                                                                  RIYCS
                                                                                                                                       COMMC
                                                                                            •
                                                                 RIZSN
                                                                                                         R2(3)
                                                                                                                                       COMMC
                          RIZCS
                                                                                            •
                                                                  R2YCS
                                                                                                         R2YSN
                          R2DOT(3)
                                                                                                                                       COMMC
                                                                  R2ZSN
                                                                                                         R3.(3)
                                                                                                                                       COMMC
                          R2ZCS ,
                                                                  R3YCS
                                                                                                          RBYSN
                          R3DOT (3)
                                                                                                                                       COMMO
                                                                  R3ZSN
                          R3ZC$
                                                                                                          R443)
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                                                                  R4YCS
                                                                                                          R4YSN
                          RADOT(3)
                                                                                                                                       COMMC
                                                                  RAZSN
                          R4ZCS
                                                                                                                                        COMMC
                                                                  SDOT
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    COMMON
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                          SINTTJ
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                                                                  SINTT3
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                          SINTT2:
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                                                                                                                                       COMMC
                                                                  SUM1
                                                                                                          SUM2
                          SP
                                                                  52(3)
                                                                                                          53(3)
                                                                                                                                       COMMO
                          SUM3
                          54(3)
                                                                                                                                        COMMC
    COMMON
                                                                  TC(393)
                                                                                                          TEMP1(3)
                          T(3,3)
                                                                                                                                       COMMC
                                                    9
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                          TEMP2 (3)
                                                                                                                                        COMMC
                                                                  TEMP4(3)
                                                                                                          TEMP5 (3,3)
  ä
                          TEMP3(3)
                                                                                                                                      COMMC
                                                                  TEMP7 (3,3)
                                                                                                          TEMP8(3,3)
                          TEMP6 (303)
                                                                                                                                      COMMO
                                                     0
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                           TEMP9 (3,3)
                                                                  TEMP10(3.3)
                                                                                                          TEMP11(3.3)
                                                                                                                                        COMMO
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                                                                  TEMP13(3,3)
                                                                                                                                        COMMO
                                                                                                          TEMP14 (3,3)
   8
                           TEMP12(3,3)
                                                     9
                                                                  TERMI(3)
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                           TEMP15(3,3)
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                                                                   71
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                           TIME
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                                                                   TJ3(10)
                           (01)SLT
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                           TMOTOR
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                                                     9
                                                                   TOTMAS
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                           TOEF (3)
                                                                                                                                        COMMO
                                                                                                          TQ16(3)
   Ф
                           T006(3)
                                                                   TQ0P (3)
                                                                                                                                        COMMO
                                                     0
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                                                                   TSTART
                                                                                                           TSTOP
                           TQIP(3)
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                                                                   TT3DOT
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                           TIEF (3)
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                                                     Q
     COMMON
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     COMMON
                           (E) OW
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                                                                   W4 (3)
                           W3(3)
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     COMMON
                           X (6,7)
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                           UMX
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     #
      ପ୍ରତ୍ୟୁକ୍ତ ବ୍ୟବ୍ୟ ପ୍ରତ୍ୟୁକ୍ତ ବ୍ୟବ୍ୟ ବ୍ୟବ୍ୟ ବ୍ୟବ୍ୟ ପ୍ରତ୍ୟୁକ୍ତ ବ୍ୟବ୍ୟ ବ୍ୟ
                                                                                                                                         PCON
      SINTTL = SIN(THETAL)
                                                                                                                                         PCON
     CUSTT: = COS (THETAL)
                                                                                                                                         PCON
     DO 30 M=1.3
                                                                                                                                         PCON
      FS = CGAINO(M) AHO(M)
                                                                                                                                         PCON
      FPT(M) =: 200ABS(FS)
                                                                                                                                         PCON
      [QOP(M) & FSOAOJ(M)
                                                                                                                                         PCON
30 CONTINUE
                                                                                                                                         PCON
      FS . . 0 .
                                                                                                                                         PCON
            (COSTT) .GT.
                                          0.87)FS =
      IF
                                                                 CGAINI (Ž) $WO (2) .
                                                                                                                                         PCON
                                                        # - CGAIN1 (2) #WO(2)
           (COSTT1 .LT. = 0.87)FS
                                                                                                                                         PCON
                                          0,87)FS =
                                                                 CGAINI (Z) 4WO (3)
      IF (SINTT)
                            e GT a
                                                                                                                                         PCON
                                      □ 0.87)FS = □ CGAIN1(2) □ WO(3)
            (SINTT) LT.
                                                                                                                                         PCON
      FPT(4) = 200ABS(FS)
                                                                                                                                         PCON
      Taip-(2) w Espaid(2)
                                                                                                                                         PCON
      FS =: CGAIN1(1) P (OMEGA] 🗝 SP)
                                                                                                                                         PCON
      FPT(5) = 2 DABS(FS)
                                                                                                                                         PCON
      TQIP(1) = psoaij(1)
                                                                                                                                         PCON
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SUBROUTINE RECALC

	******	CHANGO OF	୫ଜନନ୍ଦ୍ର ପ୍ରତମ୍ବର ପ୍ରତମ୍ବର ବର୍ଷ	***		400	୬ ଦିବ ବ ବ ଦ ବ
COMMON	A(3)	9	AE (5)	9	AED (5)	9	COMMC
<b>*</b>	AFOUR(2)	9	AII(6,3,3)	9	-		COMMC
*	A10(60303)	9	AJ2 (3)	9	ALIT _	9	Ç04MC
W #	A0CJ(6,3,3)	9	AOJ(3)	9	AONE (7)	9	COMMC
<b>⇔</b> ∡4	ATCPTZ(3,3)	9	ATHREE (5)	9	Atho (4)	9	COMMC
COMMON	A1(3 <sub>0</sub> 3)	9	Alu(2)				COMMC
COMMON #	BDMASS	9	SFOUR(2)	9	BMOM	0	COMMC
**	BODYDI(3,3)	9	BODYO1 (3,3)	8	BODY11 (3,3)	Đ	COMMC
₩.	BOMASS	9	BONE (7)	9	BTHREE (5)	Q	COMMC
45	BTW0(4)	9	Bimass	9	Bemass	9	<b>COMMC</b>
COMMON	B3MASS	9	BOMASS				COMMC
\$ 40MMON	CA(3)	,	CB (3)	9	ĈGA INO (3)	P	COMMC
 ش	CGAINI(Z)	9	**************************************		1-0-40		COMMC
<b>*</b>	COSFEJ Costti	9	COSTIJ COSTI3	9	COSTTO	ø	COMMC
<b>Ø</b>	C051	0		9	COSTT4	9	COMMC
ದ	CST	9	CP1	9	CPE	9	COMMC
COMMON	DB (3)	y	Cl DDO1(3)				COMMC
Ø	DELPAT	<b>y</b>	001(3)	9	DO&DO <sup>T</sup> (3)		COMMC
ø	DTI(3)	7	001/41	9	יטטגיטט (3)	9	COMMC
49	DTIME	9	012(3)	_	ומימו		COMMC
¢.	013007(3)	-	D13YCS	9	D13(3)	9	
¢ .	D13ZCS	9	DIBZSN	9	DIBYSN	9	COMMC
♦	D14D0T(3)	9	DJAYCS	9	D14(3)	9	COMMC
<b>♦</b>	D14ZCS:	0	DIAZSN	9	digarn	9	COMMC
COMMON	EEE (3.3)	9	EEJ(3 <sub>03</sub> )		P1 7 / 9 }		COMMC
#	EL2007(3)	9	ELZYCS	9	EL2(3)	9	<b>*</b> '' '
•	EL2ZCS	9	ELZZSN	9	ELZYSN	9	COMMC
₩	EL3007(3)	9	EL3YCS	9	ELG(3)	ß	COMMC
<b>⇔</b> .	EL3ZCS	P	ELBZSN	9	elbysn	9	COMMC
<b>#</b>	EL4007(3)	9	ELAYCS	•	elaysn	9	Соммс
<b>6</b> .	EL4ZCS	9	ELAZSN	9		9	COMMC
COMMON	FAT(8)	ν	P 6 0 5 0 16	Þ	EMI(6,6)		COMMC
<b>⇔</b> ·	FEE (6)	9	FEED(6)		FFF (3)		COMMC
Ø	FFJ (3)	9	FLAGI	9	FLAG2	8	COMMC
4	FLAGB	9	flag4	9	r lauz FN	9	COMMC
<b>ợ</b> -	FO(3)	9	FO3 (3)	9	F02(3)	9	COMMC
<b>⇔</b> ·	F03(3)	9	F 1 (3)	9	F11(3)	9	COMMC
₩-	FPT (5)	9	1 6 1 - 7	9	Lation	9	COMMC
₩	F12(3)	9 .	F13(3)		•		COMMC
COMMON	GAIN(10)	9	-63.	9			COMMO
<b>Ø</b>	G3DOT	9	<b>G</b> 4		GADOT		COMMO
COMMON	H(3)	9	HCMG (3)	<b>8</b>	HD07(3)		COMMO
6	HI (3)	9	MO(3)		HA(Q)	9	COMM
₩	H1(3)	9	H1PDÓT(3)	9 9	HIPRIM(3)	9	COMM
₩.	H3PRIM(3)	ý	HOPRIM(3)	У	use.vintal	9	COMMO
:Common	1824	9	- ICFA	<b>Q</b>	icfb	_	COMMI
<b>⇔</b> ′	ICFC'	9	icfo	۷ ç	Ž DOĆK	9	COMMI
<b>⇔</b>	IDOF (6)	9	4 41 4	¥	TROCK	P	COMM
<b>.</b> φ.	IGRAVE	9	IPNDLM	9	IPNTCK		COMM
Ø.	IPRINT	0	IPROPF	•	#1 /41 mid	¥	
COMMON	NCASE	9	NCHECK	Đ	NDECK	_	COMM(
Ģ	NGAIN	9	NUMCMG	٠	14a -a 1/	•	· · · · ·
COMMON	OMEGAI	9	OMEGA3	9 .	OMEGA4		COMM
COMMON.	PENDOL	9	PENDAL	,	AtheanA		COMM
COMMON	Q(496)	•	1997 1 W 7 Tex				e i decistif

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COMMC
COMMON
                                  RO(3)
                                                         R1(3)
            RIDOT(3)
                                   RIYCS
                                                         R1YSN
                                                                          COMMC
                                   RIZSN
                                                         R2((3)
            RIZCS
                                                                          COMMO
                                                         RZYSN
            REDOT(3)
                                   R2YC5
                                                                          COMM
                                   R2ZSN
            R2ZCS
                                                         R3.(3)
                                                                          COMM
                                   R3YCS
            REPTODER
                                                         R3YSN
                                                                          COMM
                                   R3ZSN
            RSZCS
                                                         R4(3)
                                                                          COMMO
            RADOT(3)
                                   RAYCS
                                                         R4YSN
                                                                          COMMO
                                   R4ZSN
            R4ZCS
                                                                          COMMC
COMMON
                                   SDOT
                                                         SINFEJ
                                                                          COMMC
                                  SINTTO
            SINTTJ
                                                         SINTTL
                                                                          COMMC
                                   SINTT3
                                                         SINTT4
            SINTT2
                                                                          COMMC !
                                   SUMI
                                                         SUM2
            SP
                                                                          COMMC
                                   S2(3)
            SUM3
                                                         S3(3)
                                                                          COMMC
            S4 (3)
                                                                          COMMC
                                   TC(3+3)
                                                         TEMP1 (3)
CUMMON
                                                                          COMMC
            T(3,3)
            TEMP2(3)
                                                                          COMMC
                                   TEMP4 (3)
                                                         TEMP5 (3.3)
            TEMP3'(3)
                                                                          COMMC
                                                         TEMP8(3,3)
                                   TEMP7 (3.3)
            TEMP6(3+3)
                                                                          COMMC
            TEMP9(3,3)
                                   TEMP10(3,3)
                                                         TEMP11(3.3)
                                                                          COMMC
                                                  9
                                   TEMP13(3,3)
            TEMP12(3,3)
                                                         TEMP14(3,3)
                                                                          COMMC :
            TEMP15(3:3)
                                   TERM1(3)
                                                         TERM2(3)
                                                                          COMMC .
                                   THATA (6)
                                                         THATAD (6)
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            TFRICT
                                   THETAS
            THETA1
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            THETO
                                   TIBO(3,3)
                                                          TIBOI(3,3)
                                                                          COMMC!
                                   TJ
                                                         TJ1(10)
            TIME
                                                                          COMMO
            TJ2(10)
                                   TJ3(10)
                                                         TJ4(10)
                                                                          COMMC
            TMOTOR
                                                                          COMMC
                                   TOTMAS
                                                         T01
            TOEF (3)
                                                                          COMMC
                                   TQOP (3)
                                                          TQ16(3)
            TQ0G(3)
                                                                          COMMO
                                   TSTART
                                                          TSTOP
            TQIP(3)
                                                                          COMMC
             TTIDOT
                                   TT3D0T
                                                          TTADOT
                                                                          COMMC
             71EF (3)
                                   T13
                                                          T14
                                                                          COMMC
COMMON
            V(3)
                                                                           COMMC
COMMON
            WO (3)
                                   WS
                                                          W1(3)
                                                                          COMMC
                           9
                                   W4(3)
            W3(3)
                                                                          COMMO
                           9
                                   XC
                                                          XCDOT
COMMON
            x (6,7)
                                                                          COMMC
            XMU
                                                                          COMMC
                                                                          COMMC
<del>ବର୍ଷ୍ଟ ବର୍ଷ୍ଟ ବର୍ଷ ପ୍ରତ୍ୟର୍ଷ ପ୍ରତ୍ୟର୍ଷ ବର୍ଷ ପ୍ରତ୍ୟର ବର୍ଷ ପ୍ରତ୍ୟର ବର୍ଷ ବର୍ଷ ପ୍ରତ୍ୟର୍ଷ ପ୍ରତ୍ୟର ପ୍ରତ୍ୟର ପ୍ରତ୍ୟର ପ</del>
                                                                          RECAL
SINTT1 = SIN(THETAL)
                                                                          RECAL
COSTT1 # COS(THETAL)
                                                                          RECAL
CALL SCALC
                                                                          RECAL.
EL2(1) = D12(1) + SP2(1)
                                                                          RECAL
       # D12(2) + S#S2(2)
EL2((2)
                                                                          RECAL
EL2(3) = D12(3) + S*S2(3)
                                                                          RECAL
SINTT3 = SIN(THETA3)
                                                                          RECAL
.Costt3 = Cos(theta3)
                                                                          RECAL
            PEND3L4SINTT3.
EL3(1) =
                                                                          RECAL
       = -PEND3L#COSTT3#53(3)
EL3.(2)
                                                                          RECAL
           PENDSL#COSTT3#S3(2)
EL3(3) =
                                                                          RECAL
SINTT4 = SIN(THETA4)
                                                                          RECAL
COSTT4 = Cos(THETA4)
                                                                          RECAL
           PENDAL SINTTA
                                                                          RECAL
EL4-(1) =
          -PENDAL COSTT4454 (3)
                                                                          RECAL
           PENDAL#COSTT4#54(2)
EL4(3) =:
                                                                          RECAL
R1(-1) = (BOMASS/TOTMAS)+DOI(1)
                                                                          RECAL
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END

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# - (BZMASS/TOTMAS) #ELZ(1) - (B3MASS/TOTMAS) # (D13(1) + EL3(1)) RECAL

# - (B4MASS/TOTMAS) # (D14(1) + EL4(1)) RECAL

R1(2) = (B0MASS/TOTMAS) # (D01(2) #COSTT1 + D01(3) #SINTT1) RECAL
                                                                               RECAL
         - (B2MASS/TOTMAS) SEL2(2)
         -(B3MASS/TOTMAS) #(D17(2) + EL3(2))
                                                                               RECAL
*
                                                                               RECAL
         -(84MASS/TOTMAS) * (D14(2) + EL4(2))
 R1(3) = (BOMASS/TOTMAS) * (=DO1(2) *SINTT1 + DO1(3) *COSTT1)
                                                                               RECAL
         - (BZMASS/TOTMAS) PEL2(3)
                                                                               RECAL
         -(B3MASS/TOTMAS)*(D13(3) + EL3(3))
-(B4MASS/TOTMAS)*(D14(3) + EL4(3))
#
                                                                               RECAL
                                                                               RECAL
                                                                               RECAL
 R2(1) = R1(1) + EL2(1)
                                                                               RECAL
 R2(2) = R1(2) + EL2(2)
                                                                               RECAL
 R2(3) \otimes R1(3) + EL2(3)
                                                                               RECAL
 R3(1) = R1(1) + D13(1) + EL3(1)
                                                                               RECAL
 R3(2) = R1(2) + D13(2) + EL3(2)
                                                                               RECAL
 R3(3) = R1(3) + D13(3) + EL3(3)
                                                                               RECAL
 R4(1) = R1(1) + D14(1) + EL4(1)
                                                                               RECAL
 R4(2) = R1(2) + D14(2) + EL4(2)
                                                                               RECAL
 R4(3) = R1(3) + D14(3) + EL4(3)
                                                                               RECAL
 RETURN
                                                                               RECAL
 ₩.
  #
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SUBROUTINE SCALC

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*		<b></b>			***	<u> </u>	
の かっと かっと できる かっと	<b>经企业的企业企业</b> 企业企业企业企业企业。	****	<b>የምም</b> ቀር ቀር ምር የተመሰቀው የ	***	AED (5)	***	
COMMON	A (3)	•	AE:(5)	•	ACD ( - )	•	COMM(
<b>*</b>	AFOUR(2)	•	AII(6,3,3)	•	ALIT		COMMC
*	(E+E+6)0IA (E+6+6)UOOA	•	(E).[LA (E).LOA	•	AONE (7)	•	COMMC
ö	ATCPTZ(3:3)	•	ATHREE (5)	•	ATWO(4)	•	COMMC
•	A1 (3,3)		A1J(2)	•	M11101 1	•	COMMC
COMMON	BDMASS	•	BFOUR(2)	•	BMOM .	•	COMMC
*	BODYDI (3+3)	,	BODYOT (3.3)	•	BODY11(3,3)		COMMC
*	BOMASS	•	BONE (7)	•	BTHREE (5)	,	COMMC
#	BTW0 (4)	•	BIMASS	9	BZMASS	•	COMMC
*	BBMASS	•	B4MASS				COMMC
COMMON	CA (3)	•	ÇB (3)	9	CGAINO(3)	•	COMMC
#	CGAINI(Z)	•					COMMC
₩.	COSFEJ	9	COSTŢJ	•	COSTTO	•	COMMC
<b>9</b>	COSTT1	9	COSTI3	•	COSTY4	9	COMMC
<del>ර</del> ර	COST	9	CP1.	9	CPS	•	COMMC
••	CST	9	Cl		•		COMMC
COMMON	DB (3)	9	DDO1(3)	9	D0100T(3)	٠_	COMMC
₩	DELTAT	9	DO1(3)	•	00400 (3)	ð	
₩.	DTI(3) DTIME_	9	012(3)	_	013(3)		COMMC
*	D1300T(3)	•	DISYČS	•	DISYSN	•	COMMC
6	D13ZCS	7	D13ZSN	•	D14(3)	9	COMMC
*	D14DOT(3)	6	DIAYCS	•	DIAYSN	-	COMMC
<b>.</b>	DiAZCS	9	D14ZSN	•	<b>50</b> , <b>5</b>	•	COMMC
COMMON	EEE (3+3)	9	EEJ (3,3)	•	EL2(3)	•	COMMC
<b>#</b> ,	EL2007(3)	9	EL2YCS	9	ELEYSN		COMMC
₩	EL2ZCS	9	ELZZSN	,	EL3.(3)	•	COMMC
•	EL3DOT(3)	9	EL3YCS	•	ELBYSN	,	COMMC
₩	EL3ZCS	. 9	el3ZSN	9 '	EL# (3)	9	COMMC
₩	EL4DOT (3)	•	EL4YCS	9	ELKYSN	9	COMMC
*	EL4ZCS	9	el <sup>6</sup> ZSN	9	EMI(6,6)		COMMC
COMMON	FAT(8)	9	<b>电影性的 / 4</b> .		řec		COMMC
<b>#</b>	FEE (6)	9	FEED(6)	•	FFF (3)	•	COMMC
₩ <b>6</b>	FFJ(3)	9	FLAGI	•	FLAG2	7	COMMC
*	FLAG3	<b>`9</b>	FLAGÅ FO1(3)	•	FNI .	9	COMMC
₩	FO(3) FO3(3)	9	F)(3)	•	F02(3) F11(3)	9	COMMC
<b>₩</b> .	FPT (5)	9	10101	9	P & 4 \ 1 3 '	7	COMMC
₩	F12(3)		F13(3)				COMMC
COMMON	GAIN(10)	•	63	9.			COMMC
₩	63007	•	G4.	9	GADOT		COMMC
COMMON	H(3)	,	HCMG (3)	•	HDOT(3)	,	COMMC
Φ,	HĪ (3)	9	HO(3)	,	HW'(6)	. ,	COMMC
*	H1 (3)	9	H1PDÓT(3)	•	H1PRIM(3)	9	COMMC
<i>,</i> <b>♦</b> ·	H3PRIM(3)	9	H4PRIM(3)		,		COMMC
COMMON	182F	•	<b>ICFA</b>	· •	icf8	9	COMMC
*	ice C.	•	icfd	9	IDOCK	9	COMMC
- <b>♦</b> +	IDOF(6)	9	_				ÇOMMC
<b>`♥</b> •	I GRAVE.	9	TPNDLM	•	IPNTCK	•	
<b>4</b> .	IPRINT	•	IPROPF				COMMC
COMMON	NCASE	7	NCHECK	9	NDECK	9	
<b>9</b> -	NGAIN .	- 9	NUMCMG		1010000		COMMC
COMMON	OMEGA1	•	OMEGA3	9	OMEGA4		COMMC
COMMON	PEND3L	9	PEND4L				COMMC
COMMON	Q (4 + 4)		•				COMMC

₩.

END

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COMMON
                                                         RO(3)
                                                                                              R1(3)
                     R
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                                                                                                                        COMMC
                     RIDOT(3)
                                                         RIYCS
                                                                                              RIYSN
                                                                                                                        COMMC
                                                                                 9
                                                                                              R2:(3)
                     RIZCS
                                                         RIZSN
                                             •
                                                                                 9
                                                                                                                        COMMC
                     R2D0T(3)
                                                         RZYCS
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                                                         R2ZSN
                                                                                                                         COMMC
                     R2ZCS
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                     R3DoT(3)
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                     R3ZCS
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                     84DOT(3)
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                      T(3,3)
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                      TEMP6 (3.3)
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                      TEMP12(3,3)
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                      TEMP15(3,3)
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                      X(6,7)
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 <del>ବ୍ୟବଳୟ ବ୍ୟବଳୟ ବ୍ୟବ</del>
  ٥
  نې .
  SCAL
  THIS SUBROUTINE CALCULATES THE ELEVATOR POSITION.
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                                                                                                                          SCAL
  S. a. 0.
                                                                                                                          SCAL
 RETURN
                                                                                                                         SCAL
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SUBROUTINE SDCALC

<b>*</b>							
*	•						
*****	***	**	****	*****	****	441	****
COMMON	A (3-)	•	AE(6)	•	AED (5)		COMM
	AFOUR(2)	•	AII(6,3,3)	•	<u></u>		COMM
<b>ķ</b> ī	AIO(6+3+3)	•	AJ1 (3)	9	ALIT	•	COMM
	ACCJ(6+3+3)	•	A0J(3)	•	ADNE (7)	•	COMM
<b>,</b>	ATCPT2(3+3)	•	ATHREE (5)	•	ATWO (4)	•	COMM
	A1(3,3)	•	(S) L[A				COMM
COMMON	BDMASS.	•	BFOUR (2)	•	BMOM	•	COMM
•	BODYDI (3,3)	,	BODYOI(3,3)	•	BODY11(3,3)	٠ 🛊	COMM
•	BOMASS	•	BONE (7)	•	BTHREE (5)	•	COMM
) <u>.</u>	BTWO (4)	•	BIMASS	•	BZMASS	•	COMM
	B3MASS	•	B4MASS		-		COMM
COMMON	CA(3)	9	CB (3)	•	CGAINO(3)	•	COMM
•	CGAIN1(2)	9			u.		COMM
	COSFEJ	•	COSTTJ	•	ÇOSTTO	•	COMM
•	COSTT1	•	COSTT3	•	ČOSTT4	•	COMM
•	CO2T	•	CP1	9	ČP2	•	COMM
<b>)</b>	CST	9	C1				COMM
COMMON	DB (3)	9	0001(3)	•			COMM
•	DELTAT	•	DO1(3)	•	00100T(3)	•	COMM
•	DTI(3)	•	•		•	•	COMM
•	DTIME	•	012(3)	•	013(3)	,	COMM
•	D13DOT(3)	9	DIBYCS	,	DIBYSN	•	COMM
<b>,</b>	DISZCS	•	DIBZSN	9	D14-(3)	•	COMM
<b>•</b>	D14D07(3)	9	D14YCS	•	D14YSN	•	
<b>†</b>	D14ZCS	9	D14ZSN	•		•	COMM
COMMON	EEE (3+3)	•	EEJ (3,3)	9	EL2:(3)		COMM
<b>þ</b> .	EL2001(3)	•	EL2YCS	•	ELEYSN	9	COMM
<b>ş</b> .	EL2ZCS	0	EL2Z\$N		ELB (3)	•	COMM
<b>,</b>	EL300T(3)	•	ELBYCS	•	ELBYSN	9	COMM
ş	ELBZCS	9	EL3ZSN		EL%(3)	•	COMM
• -	EL400T(3)	o	EL4YCS		ELAYSN	_	
\$	EL4ZCS	•	ELAZSN	•	EMI(6,6)	9	
COMMON	FAT(8)		CE414	•	Elast 8 4 0 1		COMM
\$	FEE (6)		FEED(6)	_	řff(3)	_	COMM
, <b>)</b>	FFJ(3)	•	FLAGI	,	A		COMM
<b>;</b>	FLAGS	,	FLAG4	•	FLAG2	9	COMM
, \$.	FO(3)	9	F01(3)	7	ÉN: É02:(3)	9	COMM
•	F03(3)	•	F1 (3)	9	F11(3)	•	ÇOMM
• •	PPT (S)	.7	F 4 ( • )	Ð	L'II (2)	Ð	COMM
•	F12(3)	9	· F13(3)				COMM
COMMON	GAIN(10)	,	G3.				COMM
	G3D0	•	64.	,	O A D O T		COMM
COMMON	8300.	9	HCMG-(3)	•	G4DOT		COMM
o o o o o o o o o o o o o o o o o o o	. HI(3) H(3)	· •	HO-(3)	9	HDDT(3)	9	COMM
• •		7		•	HW'(6)	•	COMM
•	H3 (3)	9	H1PDOT (3)	•	H1PRIM(3)	•	COMM
	H3PRIM(3)	9	HAPRIM(3)		<del>-</del>		COMM
COMMON	IB2E:	9	-igfa	•	I CFB	•	COMM
). Š	ICFC:	9	icfd	•	IDOCK	•	COMM
₹ <b>6</b> .	IDOF(6)	•		•	•		COMM
<b>\$</b> .	igrave.	9.	IPNDLM	•	IPNTCK	•	COMM
· Carre	IPRINT	•	IPROPF		<u> </u>		COMM
COMMON	NCASE	9	NCHECK	9	NDECK	•	COMM
<b>6</b>	NGAÎN.	9	NUMCMG				COMP
COMMON	OMEGA1	9	OMEGA3	9	OMEGA4		COMM
COMMON	PEND3L:	9	PEND4L				COMM
COMMON	Q(4+4)						

END.

```
RO(3)
                                                        R1(3)
                                                                        COMMC
 COMMON
                           Ø
            R
                                  RIYCS
                                                        R1YSN
            RIDOT(3)
                                                                        COMMC
                           ,
ø
                                  RIZSN
                                                        R2(3)
                                                                        COMMO
            RIZCS
÷
             R2D0T(3)
                                  R2YC>
                                                        R2YSN
                                                                        COMMC
ė
                                  R2ZSN
                                                        R3.(3)
                                                                        COMMC
             R2ZCS
⇔
                                  R3YCS
                                                        R3YSN
             R300T(3)
                                                                        COMMC
                                  R3ZSN
                                                                        COMMC
                                                        R4(3)
             RBZCS
*
                                  R4YCS
                                                        R4YSN
             RADOT(3)
                                                                        COMMC
                                  R4ZSN
             R4ZCS
                                                                        COMMC
 COMMON
                                   SDOT
                                                        SINFEJ
                                                                        COMMC
             S
                                   SINTTO
             SINTTJ
                                                        SINTT1
                                                                        COMMC
ø
*
                                   SINTT3
                                                        SINTT4
             STATE
                                                                        COMMC
6
                                                        SUM2
                                   SUMI
                                                                        COMMC
             SP
($
                                   52(3)
                                                        53(3)
                                                                        COMMC
             SUM3
                           9
                                                                         COMMC
             S4 (-3)
                                                                        COMMC
                                   TC(3+3)
                                                        TEMP1(3)
 COMMON
             T(3,3)
             TEMP2(3)
                                                                         COMMC
                                   TEMP4(3)
                                                                        COMMC
                                                        TEMP5(3+3)
             Temp3(3)
                                   TEMP7 (3:3)
                                                        TEMP8 (3,3)
(3)
             TEMP6 (3,3)
                                                                        COMMC
份
             (EQE) POMBT
                                                        TEMP11 (3,3)
                                   TEMP10(3.3)
                                                                        COMMC
ø
                                   TEMP13(3.3)
                                                        TEMP14(3,3)
             TEMP12(3,3)
                                                                        COMMC
ń
                                   TERMS (7)
                                                        TERM2(3)
             TEMP15(3:3)
                                                                         COMMC
                                   THATA(6)
                                                        THATAD (6)
             TFRICT
                                                                         COMMC
8
                                                        THETA4
₩.
             THE TAL
                                   THETAS
                                                                         COMMC
                           9
                                   TIBO(3,3)
                                                        TIB01(3,3)
٠
             THERO
                                                                         COMMC
                           9
ø
                                   7.5
                                                         7J1(10)
                                                                         COMMC
             TIME
                           9
Ħ
                                                         TJ4(10)
                                   TJ3(10)
                                                                         COMMC
             TJ2(}0)
                           9
ø
             TMOTOR
                                                                         COMMC
ø
                                   TOTMAS
                                                         TOI
                                                                        COMMC
             TOEF(3)
                                                 0
ø
                                   TQ0P(3)
                                                         TQ16(3)
             TG06(3)
                                                                         COMMC
#
                                   TSTART
                                                         TSTOP
                                                                         COMMC
             TQ1P(3)
ø
                                   TTODOT
                                                         TTADOT
                                                                         COMMC
             TTIDOT
₩.
                                                         714
             71EP(3)
                                   713
                                                                         COMMC
                            .
 COMMON
             V(3)
                                                                         COMMC
                                   WS
                                                                         COMMC
  COMMON
             WO(3)
                                                         W1 (3)
                                   W4-(3)
             W3(3)
                                                                         COMMC
                                   XC
                                                         XCDOT
  COMMON
             x (6,7)
                                                                        COMMO
             XMU
                                                                         COMMC
                                                                         COMMC
  *
  ⇔.
  សង្គប់ស្ត្រីក្រុងស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត្រីស្ត
                                                                         SDCAL
  THIS SUBROUTINE CALCULATES THE ELEVATOR VELOCITY.
                                                                         SDCAL
                                                                         SDCAL
  SDOT to Oo.
                                                                         SDCAL
  RETURN
                                                                         SDCAL
                                                                         SDCAL
  ۵.
```

```
SUBROUTINE SYEQNS(A+N.NR+NC.FLAG)
C
      *
0000
      **********************************
                                                                         SYEON
               LINEAR SIMULTANEOUS EQUATIONS
                                                                         SYEON
Ċ
              AUGMENTED MATRIX (AC)
                                        WHERE
                                                  AX = C
                                                                         SYEON
C
                    DATA DESTROYED
          ORIGINAL
                                                                         SYEON
C
              NUMBER OF EQUATIONS
                                                                         SYERN
C
                                   COLUMN
                                             N+1 OF MATRIX, A
                        WILL BE
                                                                         SYEON
          SOLUTION
                        SOLUTION EXIST
                                                     NO SOLUTION
C
                                                                         SYEQN
                                            F= 1.0
          FLAG # 0.
                                                                         SYERN
      DIMENSION A (NR, NC)
                                                                         SYEGN
      NT = N
                                                                         SYEQN
      N2 = N1+1
      NO # N1 -1
                                                                         SYERN
      FLAG = 0.
                                                                         SYEQN
      DO
         60 I ±1.N1
                                                                         SYEON
      M m I
                                                                         SYEGN
      MI = M
                                                                         SYEGN
                                                                         SYERN
      IF (MI =N1)2,12,2
                                                                         SYEGN
 2
      DO 10 II mm NO
      IF ( ABS(A(MI,M)) = ABS(A(II+1,M))) 5:10:10
                                                                         SYEON
      FIND LARGEST ABSOLUTE VALUE COLUMN M...
                                              CALL IT
                                                                         SYEGN
 5
                                                                         SYERN
      MI # II+ 1
      CONTINUE
 10
                                                                         SYEGA
 12
      BIG # A(MI.M)
                                                                         SYEGN
      IF( BIG ) 15,100,15
                                                                         SYEGN
      BIG . O IMPLIES THERE IS NO SOLUTION
C
                                                                         SYEON
 15
      IF (MI- M) 18.25.18
                                                                         SYEON
 18
      SNOM# LC 02 OD
                                                                         SYEGN
                                                                         SYERN
      TEMP MA (Maul)
      A(M)JJ) = A(MI,JJ)/BIG
NORMALIZE ROW MI AND EXCHANGE WITH ROW M
                                                                         SYEGN
                                                                         SYEGN
 20
      A(MI,JJ) = TEMP
                                                                         SYEGN
      GO TO 35
                                                                         SYERN
      DO 30 JJ#M.N2
 25
                                                                         SYEGN
      NORMALIZE ROW M
                                                                         SYEGN
 30
      DIB\(LL,M)A= (LL,M)A
                                                                         SYEQN
 35
      DO 50 II # 1.N1
                                                                         SYEGN
      DO ROW OPERATIONS TO ZERO ELEMENTS OF COLUMN M EXCEPT FOR
                                                                         SYEGA
      ELEMENT A (MOM)
C
                                                                         SYEQN.
      TEMP - #A(II,M)
                                                                         SYEGN
      IF (M=II) 38,50,38
                                                                         SYEQA'
 38
      IF(TEMP) 39.50.39
                                                                         SYEQN.
 39
      DO 40 JJ# M.N2;
                                                                         SYEO
      (LL,M)A* 9M3T -(LL,II)Am(LL,II)A
                                                                         SYEON
 40
      CONTINUE
                                                                          SYER
      CONTINUE
 50
                                                                         SYEGH
 60
      CONTINUE
                                                                         SYEON
 70
      RETURN
                                                                         SYEGN
      READ SOLUTION AS N ELEMENTS FROM COLUMN (N+1)
                                                                          SYEGN
 100
      FLAG #1.0
                                                                         SYEOP
         SORRY THE COEFFICIENT MATRIX IS SINGULAR
C
                                                                          SYEGH
      RETURN
                                                                          SYEGH
¢
                                                                          SYEGI
C
      Č
      ₩.
      *-
      END
```

<b>♦</b>	E TORKOL						
ø							
<b>*</b>	•		•	•			
		<b>会体会体</b> 体	000000000000000000	ቀ ያውር ው			_
COMMON	A(3)	9	AE (5)	9	aed (5)	. \$	COMMO
<b>₩</b>	AFOUR(2)	Ð	AII (6,3,3)	\$	· · · •		COMM
ా ర	AIO(60303)	9	AJ1 (3)	9	ALIT	9	· · · ·
₩	AOCJ(6,3,3)	9	AOJ(3)	9	ADNE (7)	9	COMMO
₩	ATCPTZ(3,3)	9	ATHREE (5)	9	atho (4)	9	COMMO
	A1 (3,3)	9	AlJ(Z)		-14-		COMMO
COMMON	BDMA5S	9	BFOUR (2)	9	BMOM	9	
<b>⇔</b> <b>⇔</b>	BODYDI (3+3)	9	BODYO1 (3,3)	9	BODA11(303)	9	COMMO
". Ø	BOMASS	•	BONE (7)	9	BTHREE (5)	9	COMMO
**	BTWO(4)	•	B1MAS5	Đ	Bemass	9	
	B3MASS	•	BAMASS				COMMO
COMMON	CA (3)	9	CB (3)	9	CGAINO(3)	\$	9
c)	CGAINI(2)	9	ocett.		0224		COMMO
<b>\$</b>	COSFEJ	9	COSTI	9	COSTTO		COMMO
₩	COSTTI	9	COSTT3	9	COSTTO	ò	COMMO
₩ ₩	COZT	Đ	CP1	9	CP2	ĝ	COMMO
COMMON	.cst	Ø	Cl				COMM
#	DB (3)	9	DD01(3)	9	AA1849494		COMMO
Ø	DELTAT	9	DO1(3)	9	001007(3)	ç	COMMO
<b>4</b>	071(3)	9	220131				ÇOMMO
ø	DTIME	9	015(3)	9	013(3)	0	<b>37</b>
i i	D13DOT(3)	Đ	D13YCs	9	DJ3YSN	٥	COMMO
<b>*</b>	DISZCS	9	D2325N	9	D\$4(3)	9	COMM
₩.	D14D07(3)	9	DIAYES	9	digysn	9	COMMO
COMMON	Diazes	9	D14ZSN				Commo
& COMMON	EEE (303)-	9	EEJ(3,3)	9	EF5(3)	ø	
÷	EL 2007 (3)	9	ELZYCS	9	eleysn	ê	COMM
	ELZZCS	P	ELZZSN	9	EPB (3)	9	COMM
., 46	EL300 (3)	9	ELBYCS	Ø	elbysn	9	COMM
ф Ф	EL3ZCS	9	ELBZSN	g	EL#(3)	9	COMM
\$	EL4DOT(3) EL4ZCS	9	el4ygs	9	elaysn	9	COMM
COMMON		9	EL4ZSN	9	EMI(6,6)		COMMI
\$ COMMON	FAT (8)	9	memo (A)				COMM
•	PEE (6)	9	FEED (6)	Ģ	fff (3)	9	COMM
₩	FFJ(3)	Þ	FLAGL	9	FLAGE	9	COMM
	FLAG3	0	FLAG4	8	FNI	Ş.	COMM
40	FO(3) FO3(3)	9	FO1(3)	Ŷ	F08 (3)	ð	COMM
6	661 (2)	9	F] (3)	9	F\$1(3)	ð	COMM
₩ <b>&amp;</b> -1		9	# 9 m / 73 k				COMM
COMMON	F12(3)	9	F13(3)				ÇOMM
COMMUN S	GAIN(10)	9	.63	9			COMM
COMMON	G3D07	9	G4	9	GADOT		COMM
S COMMON	H(3)	9	HCMG(3)	9	HD07(3)	ŷ	<b>⇒</b> -
<b>\$</b>	HI (3)	9	HO (3)	9	HQ1(Q)	9	- COMM
· <b>4</b>	H1 (3)	9	H1P00T(3)	ĝ	Hiprim(3)	9	Comm
	H3PRIM(3)	9	HAPRIM(3)		• _		COMM
COMMON	IB2F	9	·ICFA	9	icfo	9	COMM
₩.	ICFC-	0	icfd	9	idock	9	<u> </u>
Ġ	IDOF(6)	9	mana in				COMM
ø i	IGRAVE	9	IPNOLM	9	ipnyck	Ŷ	
	IPRINT	9	IPROPF		<b>15.</b> pm -s		СОММ
COMMON	NCASE	9	NCHECK	0	NDECK	9	COMM
CUMMON .	NGAIN	9	NUMCMG				COMM
COMMON	OMEGAL	9	OMEGA3	9	omega4		COMM
	144 PT D ( 170 PT )		UCHISAL				
COMMON COMMON	PEND3L Q(4+4)	9	PENDAL				COMM

```
COMMON
                                    RO(3)
                                                         R1 (3):
                                                                         COMM(
           tin R
                                                  •
              RIDOT(3)
                                    RIYCS
                                                         RIYSN
                                                                         COMM(
                                    RIZSN
                                                         R2(3)
              RIZCS
                                                                         COMMC
              R2D0T(3)
                                    R2YCS
                                                         R2YSN
                                                                         COMM
                                    R2ZSN
                                                         R3(3)
              R2ZCS
                                                                         COMM
              R3DoT(3)
                                    R3YCS
                                                         R3YSN
                                                                         COMMO
                                                         R4(3)
              R3ZCS
                                    R3ZSN
                                                                         COMMO
                                    RAYCS
                                                         RAYSN
              RADOT(3)
                                                                         COMMO
                                    R4ZSN
              R4ZCS
                                                                         COMMO
  COMMON
                                    SDOT
                                                         SINFEJ
                                                                         COMMC
                                    SINTIO
                                                         SINTTL
              SINTTJ
                                                                         COMMO
                                    SINTT3
                                                         SINTT4
              SINTTZ
                                                                         COMMC
                                    SUM1
                                                         SUMZ
              SP
                                                                         COMMC
                                    S2(3)
                                                         S3(3)
              SUH3
                                                                         COMMC
              54(3)
                                                                         COMMC
  COMMON
              T(3.3)
                                    TC(3+3)
                                                         TEMP1(3)
                                                                         COMMC
              TEMP2 (3)
                                                                         COMMC
                                                         TEMP5 (3,3)
                                    TEMP4(3)
              TEMP3(3)
                                                                         COMMC
                                    TEMP7 (3.3)
                                                         TEMP8 (3+3)
              TEMP6(3+3)
                                                                         COMMC
              TEMP9 (3,3)
                                    TEMP10(3,3)
                                                         TEMP11(3.3)
                                                                         COMMC
                                    TEMP13(3,3)
                                                         TEMP14(3.3)
              TEMP12(3,3)
                                                                         COMMC
              TEMP15(3,3)
                                    TERM1(a)
                                                         TERM2(3)
                                                                         COMMC
              TFRICT
                                    THATA (6)
                                                         THATAD(6)
                                                                         COMMC
                                    THE TA3
                                                         THETA
              THETAL
                                                                         COMMC
                                    TIBO(3.3)
              THETO
                                                         TIBOI (3,3)
                                                                         COMMO
              TIME
                                    TJ
                                                         TJ1(10)
                                                                         COMMC
                                    TJ3(10)
              (01)SLT
                                                         TJ4(10)
                                                                         COMMC
              TMOTOR
                                                                          COMMC
              TOEF (3)
                                    TOTMAS
                                                         TOI
                                                                         COMMO
                                    TOOP (3)
                                                         TQ1G(3)
              TQOG(3)
                                                                         COMMO
                                    TSTART
              TQ1P(3)
                                                         TSTOP
                                                                         COMMO
                                    TT3D0T
              TTIDOT
                                                         TT4D0T
                                                                         COMMC
              T1EF (3)
                                    T13
                                                         T14
                                                                          COMMC
   COMMON
              · V (3)
                                                                          COMMC
   COMMON
              WO (3)
                                    WS
                                                         W1 (3)
                             .
                                                                         COMMC
                                    W4-(3)
              W3(3)
                             9
                                                                          COMMC
   COMMON
                                    ХC
                                                         XCDOT
              X(6<sub>5</sub>7)
                                                                         COMMC
              XMU
                                                                          COMMC
                                                                          COMMC
   ***********************************
                                                                          TORKC
   THIS SUBROUTINE COMPUTES THE TORQUE BETWEEN BODY 0 AND BODY 1.
                                                                          TORKC
   THIS TORQUE CONSISTS OF THE CONTROL TORQUE AND FRICTION TORQUE.
                                                                          TORKO
                                                                          TORKO
    IF (TIME .NE. TSTART) GO TO 10
                                                                          TORKC
    XC##GAIN(2) #OMEGA1
                                                                          TORKC
    AFOUR (2) WXC
                                                                          TORKC
10
     CONTINUE
                                                                          TORKE
    AFOUR (1) STIME
                                                                          TORKC
    BFOUR (1) =DELTAT
                                                                          TORKE
    XQDOTEGAIN(3) + (OMEGA1=SP)
                                                                          TORKE
    BFOUR (2) #XCDOT
                                                                          TORKO
   CALL FOMS (AFOUR, BFOUR, 2, FLAG4, TJ4)
                                                                          TORKC
    XCHAPOUR (2)
                                                                          TORKC
    TMOTOR=GAIN (2) #OMEGA1+XC
                                                                          TORKE
    TFRICT=GAIN(1)#SIN(OMEGA1)
                                                                          TORKO
    TO1=TMOTOR+TFRICT
                                                                          TORKE
   RETURN
                                                                          TORKO
```

SUBROUTINE XDOT

*						
 <b>#</b>	•					
***	***	***	****	****	*******	****
COMMON	A(3)	•	AE (5)	•	AED (5)	. COMM
1	AFOUR(2)	•	AII (6,3,3)	•	. •	COMM
	A10(6:3:3)	•	AJ1 (3)	•	ALIT	• COMM
,	AOCJ (6,3,3)	•	A0J(3)	•	ADNE (7)	• COMM
	ATCPT2(3,3)	•	ATHREE (5)	•	ATWO (4)	. COWN
	A1 (3.3)	•	A1J(2)			COMM
COMMON	BDMAS\$	•	BFOUR (2)	•	BMOM	• COMM
	BODYDI (3,3)	9	BODY01(3,3)	•	BODY11(3,3)	9 COMM
	BOMASS	9	BONE (7)	•	BTHREE (5)	• COMM
	BTWO(4)	•	BIMASS	•	BZMASS	• COMM
	Bamass	•	84MASS			COMM
COMMON	CA(3)	•	CB (3)	•	CGAÍNO (3)	COMM
	CGAIN1(2)	9	COCTT.		Sectto	COMM
	COSFEJ	9	COSTIJ	•	COSTTO	• COMM
	COSTT1	•	COSTT3	•	COSTT4	COMM
•	COZT	•	CP1	•	CP2	• COM
COMMON	·cst	9 '	C1			COMP
COMMON	DB (3)	9	DD01(3)	•	DA1DAT (3)	COMP
•	DELTAT	•	DO1(3)	•	D01D0T(3)	, ÇOM
<del>.</del>	DTI(3)	•	D12(3)	-	612121	COMP
•	DTIME D13DOT(3)	•	DIBYCS	•	D13(3) D13Y5N	• COM
, ,		y -	DISTOS	9		P COMP
· •	D13ZCS D14D <b>0</b> T(3)	9	D14YCS	•	D14(3) D14Y5N	, COMA
	D14ZCS	,	D14ZSN	7	ייכודעע	P COMP
COMMON	EEE (3+3)	•	EEJ(3,3)		EL2(3)	• COMP
A Line	EL200T(3)	•	ELZYCS	•	ELZYSN	9 COMP
•	ELZZCS.	9	ELZZSN	•	ELB(3)	9 COM
	EL300T(3)	•	ELSYCS	•	ELBYSN	A COW
)-	EL3ZCS	•	ELBZŚN	•	EL4(3)	A COMP
,	. EL400T(3)	•	ELAYCS	,	EL4YSN	• COM
	EL4ZCS	•	EL4ZSN	4	EM(6,6)	COMP
COMMON	FAT(8)	•	<b>E</b> #4 14	,	Emily 47	COM
	FEE (6)	.9	FEED (6)	•	FFF (3)	• COM
	FFJ(3)	•	FLAGI	,	FLAG2	COM
•	FLAG3	•	FLAG4	•	FNI	COM
• •	FO(3)	·	F01(3)	9	F02(3)	, COM
i '	F03(3)	. •	F1(3)	9	F11(3)	• COM
,	FPT (5)	9	, = ,	•	7 4 4 1 - 7	COM
	F12(3)	9	F13(3)			ÇOM
COMMON	GAIN(10)	9	<b>63</b>	•	•	COM
,	63007	9	Ĝ <b>4</b>	•	G4D0T	COM
COMMON	H(3)	•	HCMG (3)	•	HDOT (3)	• ČOM
•	HI (3)	•	HO (3)	•	HM(6)	COM
•	H1 (3)	9	H1PDOT(3)	•	HIPRIM(3)	• COM
•	H3PRIM(3)	9	HAPRIM(3)		,	COM
COMMON	182Ē	9	ICFA .	,	ĬCFB	COM
	ICFC:	9	ICFD	9 1	IDOCK	COM
ý	IÓOF(6)	9	. •		=	COM
ì	IGRAVE	9	-IPNDLM	•	<b>IPNTCK</b>	• ÇOMI
<b>)</b> .	IPRINT	9	IPROPF	-	<u>-</u> ···• ·	ÇOMI
COMMON	NCASE'	9	NCHECK	9	NDECK	. COM
)	NGAIN	•	NUMCMG		. , .	COM
COMMON	OMEGA1	•	OMEGA3	•	OMEGA4	COM
COMMON	PENDSL	•	PEND&L	-	<u>-</u>	ÇOM
COMMON	Q.(4,4)	•				COM

```
RO(3)
 COMMON
                                                          R1(3)
             R
                            .
                                                                         9 COMPIC
                                                  •
             RIDOT(3)
                                    RIYCS
                                                          RIYSN
                                                                           COMMC
             RIZCS
                                    RIZSN
                                                          R2'(3)
                                                                           COMMC
                                    RZYCS
                                                          RZYSN
             R200T(3)
                                                                           COMMC
                                    R2ZSN
             R2ZCS
                                                          R3.(3)
                                                                           COMMC
             R3DOT(3)
                                    R3YCS
                                                          R3YSN
                                                                           COMMC
             RZZCS
                                    R3ZSN
                                                          R4.(3)
                                                                           COMMC
             RADOT(3)
                                    R4YC5
                                                          R4YSN
                                                                           COMMC
             R4ZCS
                                    R4ZSN
                                                                           COMMO
                                    SDOT
 COMMON
                                                          SINFEJ
                                                                           COMMC
             SINTTJ
                                    SINTTO
                                                          SINTT1
                                                                           COMMC
                                    SINTT3
                                                          SINTT4
             SINTT2
                                                                           COMMC
             SP
                                    SUM1
                                                          SUM2
                                                                           COMMC
                                    S2(3)
             SUM3
                                                          $3'(3)
                                                                           COMMC
              $4(3)
                                                                           COMMC
 COMMON
              T(3.3)
                                    TC(3.3)
                                                          TEMP1 (3)
                                                                         . COMMC
              TEMP2(3)
                                                                           COMMC
                                    TEMP4 (3)
              TEMP3(3)
                                                          TEMP5 (3.3)
                                                                           COMMC
                                    TEMP7 (3+3)
              TEMP6(3+3)
                                                          TEMP8 (3+3)
                                                                          COMMC
              TEMP9 (3,3)
                                    TEMP10(3,3)
                                                          TEMP11(3,3)
                                                                           COMMC
              TEMP12(3,3)
                                    TEMP13(3.3)
                                                          TEMP14(3,3)
                                                                          COMMC
                                    TERML(3)
              TEMP15 (3,3)
                                                          TERM2 (3)
                                                                           COMMC
              TFRICT
                                    THATA(6)
                                                          THATAD(6)
                                                                           COMMC
              THE TAL
                                    EATSHT
                                                          THETAS
                                                                           COMMC
ė
                                    TIBO(3,3)
              THETO
                                                          (E & E) 1081T
                                                                           COMMC
                                    ŦJ
              TIME'
                                                          TJ1(10)
                                                                           COMMC
#
                                    TJ3(10)
                                                          TJ4(10)
              (10) SLT.
                                                                           COMMC
٠
              TMOTOR
                                                                           COMMC
ŧ
                                    TOTMAS
              TOEF (3)
                                                          TO1
                                                                           COMMC
              T000(3)
                                    TOOP (3,
                                                          TQ16(3)
                                                                           COMMC
                                    TSTART
                                                          TSTOP
              TQ1P(3)
                                                                           COMMC
              TT1DOT
                                    TT3DOT
                                                          TTADOT
                                                                           COMMC
              T1EF(3)
                                    T13
                                                          714
                                                                           COMMC
  COMMON
              V (3)
                                                                           COMMC
                                    WS
  COMMON
              MO (3)
                                                          W1(3)
                                                                           COMMC
                                    W4 (3)
              W3(3)
                                                                           COMMO
  COMMON
                                    XÇ
              x(6,7)
                                                           XCDOT
                                                                           COMMC
              XMU
                                                                           COMMO
                                                                           COMMC
  ¥
  XDOT
  SINTT1 =: SIN(THETAL)
                                                                           XDOT
  COSTT1 # COS (THETAL)
                                                                           XDOT
  W1(1) = WO(1) + OMEGA1
                                                                           XDOT
  W^{1}(2) = W_{0}(2) + COSTT^{1} + W_{0}(3) + SINTT^{1}
                                                                           XDOT.
  W1(3) = +W0(2) +SINTT1 + W0(3) +COSTT1
IF (TIME •NE. TSTART) GO TO 2
                                                                           XDOT
                                                                           KDOT
  CALL RECALC
                                                                           XDOT
2 CONTINUE
                                                                           XDOT
  CALL SDCALC
                                                                           XDOI
  EL2DOT(1) = -W1(3) + EL2(2) + W1(2) + EL2(3) + S2(1) + SDOT
                                                                           XDOT
  EL2DOT(2) a W143}*EL2(1) • W1(1)*EL2(3) • S2(2)*Snot
                                                                           XDOT
  EL2DOT(3) = -W1(2)^{H}EL2(1) + W1(1)^{H}EL2(2) + S2(3)^{H}SDOT(3)
                                                                           XDOT
  RO(1) \approx RI(1) \Rightarrow DOI(1)
                                                                           XDOT
  RO(2) = R1(2)*COSTT( - RI(3)*SINTTI - DOI(2)
RO(3) = R1(2)*SINTTI + RI(3)*COSTTI - DOI(3)
                                                                           LOCK
                                                                           YOOY
  W3(1) = W1(1)
                                                                           YOUX
  W3 (2) - # OMEGA3#S3 (2) + W1 (2)
                                                                           TOOX
```

```
W3(3) # OMEGA3#53(3) + W1(3)
EL3DOT(1) # -W3(3) *EL3(2) + W3(2) *EL3(3)
                                                                          XDOT
                                                                          XDOT
 EL3DOT(^{\circ}) = W3(3)*EL3(1) = W3(1)*EL3(3)
                                                                          XDOT
 EL3DOT( 1) = -W3(2) *EL3(1) + W3(1) *EL3(2)
                                                                          XDOT
 W4(1) = W1(1)
                                                                          XDOT
 W_4(2) = OMEGA4454(2) + W1(2)
                                                                          XDOT
 W^4(3) = OMEGA4*S4(3) + W1(3)
                                                                          XDOT
 ELADOT(1) # -W4(3) #EL4(2) + W4(2) #EL4(3)
                                                                          XDOT
               W4(3) *EL4(1) - W4(1) *EL4(3)
 EL4DOT(2) =
                                                                          XDOT
 EL4DOT(3) = -W4(2) *EL4(1) + W4(1) *EL4(2)
                                                                          XDOT
 DOIDOT(1) \neq -WO(3) + DOI(2) + WO(2) + DOI(3)
                                                                          XDOT
 D01D0T(2) #
               WO(3) *DO1(1) = WO(1) *DO1(3)
                                                                          XDOT
 D01D0T(3) = -wo(2) + D01(1) + wo(1) + D01(2)
                                                                          XDOT
 01300T(1) = -W1(3)+013(2) + W1(2)+013(3)
                                                                          XDOT
 D13D0T(2) = W1(3)*D13(1) = W1(1)*D13(3)
                                                                          XDOT
 D13D0T(3) = -w1(2)+D13(1) + w1(1)+D13(2)
                                                                          XDOT
 D14D0T(1) = -W1(3)+D14(2) + W1(2)+D14(3)
                                                                          XDOT
 D14D0T(2) =
               W1(3)*D14(1) - W1(1)*D14(3)
                                                                          XDOT
 D14D0T(3) = W1(2)*D14(1) + W1(1)*D14(2)
                                                                          XDOT
 RIDOT(1) = (BOMASS/TOTMAS) *DOIDOT(1)
                                                                          XDOT
            *(B2MASS/TOTMAS) #EL2DOT(1)
                                                                          XDOT
            -(B3MASS/TOTMAS) *(D13DOT(1) + EL3DOT(1))
-(B4MASS/TOTMAS) *(D14DOT(1) + EL4DOT(1))
                                                                          XDOT
                                                                           XDOT
 RIDOT(2) # (BOMASS/TOTMAS) # (DOIDOT(2) #COSTT1 + DOIDOT(3) #SINTT1)
                                                                           XDOT
#
            - (B2MASS/TOTMAS) #EL2DOT(2)
                                                                           XDOT
٠#٠
            -(B3MASS/TOTMAS) + (D13DOT(2) + EL3DOT(2))
                                                                           XDOT
            -(B4MASS/TOTMAS) + (D14DOT(2) + EL4DOT(2))
                                                                           XDOT
 RIDOT(3) = (BOMASS/TOTMAS) + (+DOIDOT(2) +SINTT1 + DOIDOT(3) +COSTT1)
                                                                          XDOT
            - (B2MASS/TOTMAS) #EL2DOT (3)
                                                                           XDOI
₩
            -(B3MA$$/TOTMA$) + (D13DOT(3) + EL3DOT(3))
                                                                           XDOI
ö
            - (B4MASS/TOTMAS) + (D14DOT(3) + EL4DOT(3))
                                                                           XDOT
 R2DOT(1) #: R1DOT(1) + EL2DOT(1)
                                                                           XDOT
 R2DOT(2) \Rightarrow R1DOT(2) \Rightarrow EL2DOT(2)
                                                                           XDOT
 R2DOT(3) \Rightarrow R1DOT(3) + EL2DOT(3)
                                                                           XDOT
 R3DOT(1) = R1DOT(1) + D13DOT(1) + EL3DOT(1)
                                                                           XDOT
 R3DOT(2) = R1DOT(2) + D13DOT(2) + EL3DOT(2)
                                                                           XDOT
 RBDOT(3) #:R1DOT(3) + D13DOT(3) + EL35OT(3)
                                                                           XDOT
 R4DOT(1) = R1DOT(1) + D14DOT(1) + EL4ñOT(1)
                                                                           XDOT
 R4DOT(2) = R1DOT(2) + D14DOT(2) + EL4DOT(2)
                                                                           XDOT
 R4DOT(3) \Rightarrow R1DOT(3) + D14DOT(3) + EL4DOT(3)
                                                                           XDOT
 CALL MULT (HO, BODYOI, WO, DUM, DUM, DUM, 1)
                                                                           XDOT
 CALL MULT (H1.BODY1I.W1.DUM.DUM.DUM.1)
                                                                           XDOT
 H3PRIM(1) = B3MASS*(~EL3(3)*R3DOT(2) & EL3(2)*R3DOT(3))
                                                                           XDOT
 H3PRIM(2) = B3MASS*( EL3(3)*R3D07(1) = EL3(1)*R3D07(3))
                                                                          XDOT
 H3PRIM(3) = B3MASS*(=EL3(2)*R3DOT(1) + EL3(1)*R3DOT(2))
                                                                          XDOT
 H4PRIM(1) \approx B4MASS#(=EL4(3)*R4DOT(2) + EL4(2)*R4DOT(3))
                                                                          XDOT
 H4PRIM(2) = B4MASS#( EL4(3) #R4DOT(1) = EL4(1) #R4DOT(3))
                                                                          XDOT
 H4PRIM(3) # B4MASS*(PEL4(2) PR4DOT(1) + EL4(1) PR4DOT(2))
                                                                          XDOT
 HIPRIM(2) + HI(2) + H3PRIM(2) + H4PRIM(2)
                                                                           XDOT
   -B2MASS+( - EL2(3)+R2DOT(1) + EL2(1)+R2DOT(3))
                                                                          XDOT
   -B3MASS*( - D13(3)*R3DOT(1) + D13(1)*R3DOT(3))
-B4MASS*( - D14(3)*R4DOT(1) + D14(1)*R4DOT(3))
                                                                          XDOT
                                                                          XDOT
 H1PRIM(3) + H1(3) + H3PRIM(3) + H4PRIM(3)
                                                                          XDOT
   -B2MASS+( EL2(2) *R2DOT(1) - EL2(1) *R2DOT(2))
                                                                          XDOT
   -B3MASS*( D13(2) 4R3DOT(1) - D13(1) 4R3DOT(2))
                                                                          XDOT
   -B4MASS#( D14(2)#R4DOT(1) - D14(1)#R4DOT(2))
                                                                          XDOT
 IF (TIME .NE. TSTART) GO TO 5
                                                                          XDOT
 H1PRIM(1) = H1(1) + H3PRIM(1) + H4PRIM(1)
                                                                           XDOT
XDOT
   -BEMASS*(D13(3)*R3DOT(2) - D13(2)*R3DOT(3))
                                                                           XDOT
   -84MASS+(D14(3) +R4DOT(2) - D14(2) +R4DOT(3))
                                                                          XDOT
 LET US DEFINE SOME INTERMEDIATE VALUES NEEDED TO COMPUTE H.
                                                                           XDOT
```

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```
* B2MASS*R2DOT(1)
      SUM1 m BIMASSOR 1007 (1)
                             * B4MASSGR4DOT(1)
            +B3MASS*R3DOT(1)
      SUM2 a BlMASSORIDOT(2) + B2MASSOR2DOT(2)
                             + B4MASSOR4DOT(2)
            (S) TODER BRANEBO
      SUM3 & BIMASSORIDOI(3)
                             . BZMASSERZDOT (3)
            +83MASSOR3DO (3) + B4MASSER4DO (3)
     ф
      CALCULATE HO
C
      DO 4 Inlo3
      HCMG(I) = FFF(I)
      DO 4 JE1,3
      HCMG(I) & EEE(IOJ) ONO(J) O HCMG(I)
    4 CONTINUE
      H(1) = HO(1) \Rightarrow H1PRIM(1)
            +(=DO1(3) COSTT1 + DO1(2) SINTTT) SUHZ
     #
     o( DOI(3) ØBINTTI o DOI(2) COSTTITOSUM3
     Ħ
            + HCMG(1)
      H(2) - HO(2) . COSTTICHIPRIM(2) - SINTTICHIPRIM(3)
            + DO1(3) 05UM1 - DO1(1) 05INTT1 5UM2 - DO1(1) 0COSTT1 5UM3
     Ø.
            + HCMG(2)
      H(3) = HO(3) + SINTTIOHIPRIM(2) + COSTTIOHIPRIM(3)
            - DO1(2) -SUM1 + DO1(1) -COSTT1 -SUM2 - DO1(1) -SINTT1 -SUM3
            + HCMG(3)
    5. CONTINUE
      COMPUTE THE UNIT VECTOR JI.
C
      AJI(1) = B2MASSOEL2(1)
               *B3MASS*D13(1) * B3MASS*EL3(1)
               +BAMASSODI4(1) + BAMASSOEL4(1)
      AJ1(2) = B2MASS@EL2(2)
     ∯ .
               .BAMASSODIA(2) . BAMASSOEL4(2)
      AJI(3) = B2MASSOEL2.(3)
               OBBMASSODIB(3) + BBMASSOELB(3)
               OBOMASSODIA(3) O BAMASSOEL4(3)
      "UPDATE THE ORBIT ANGLE
C
      THETO & TIME WS
      IF: (IGRAVF .EQ. 0) GO TO 10
      CALCULATE THE GRAVITY GRADIENT FORCES AND TORQUES.
C
   CALL GGRAD
10 CONTINUE
      SUM THE FORCES ON BODY ZERO.
C
      FO(1) # FO1(1)
      FO(2) & FO1(2)
      F9(3) & F01(3)
      SUM THE FORCES ON BODY ONE.
C
      F1(1) & F11(1)
      F1(2) = F11(2)
      F1(3) = F11(3)
       SUM THE TORQUES ON BODY ZERO.
C
       TOEF(1) = TQOG(1) + TQOP(1)
       [Ogf(2) = TQOG(2) + TQOP(2)
       TOEF (3) = TQOG (3) + TQOP (3)
       SUM THE TORQUES ON BODY ONE.
C
       TLEF(1) & TQIG(1) + TQIP(1)
       TIEF(2) 0. TOIG(2) + TOIP(2)
       Tlef (3) = TQ1G(3) + TQ1P(3)
       LET US DEFINE SOME INTERMEDIATE TERMS USED TO CALCULATE HOOT.
¢
       TERMI(1) = (BOMASS = TOTMAS) ODO1(1) = AJI(1)
       TERMI(2) = (BOMASS = TOTMAS) DOI(2)
         - COSTTIMAJI(2) + SINTTIMAJI43)
       TERML(3) = (BOMASS - TOTMAS) ODOL(3)
      a - Sintliaji(2) - Cosiliaji(3)
       TERM2(1) = BOMASSODO1(1) - AJ1(1)
```

XDOT

XDO?

YOOK

XDOT

XDOY.

XDOY

XDOT

XDOT

**XDOT** 

XDOT

XDOT

XDOT

XDOT

XDOT

XDOT YDOT

KOOT

XDOT

XDOT

TOGX

TOQX TOQX

YOUY

TOOK

XDOT

TOOX

TOCK

YOUX

KDOT

XDOT XDOT

YOOK

YOUX

XDOT

YDOT

KDOT

XDOT

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XDOT

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TERM2(2) # BOMASS*( COSTTI*DO1(2) * SINTTI*DO1(3)) * AJ1(2)
                                                                    XDOT
TERM2(3) = BOMASS*(=SINTT1*DO1(2) + COSTT1*DO1(3)) - AJ1(3)
                                                                    XDOT
               0.
                                                                    XDOT
ATCPT2(1+1) #
               -TERM2 (3)
                                                                    XDOT
ATCPT2(1+2) =
ATCPT2(1+3) =
                TERM2 (2)
                                                                    XDOT
                COSTTINTERM2(3) + SINTTINTERM2(2)
                                                                     XDOT
ATCPT2(2:1) =
ATCPT2(292) = =SINTT1+TERM2(1)
                                                                     XDOT
ATCPT2(2:3) =
                                                                     XDOT
               -COSTT1+TERM2(1)
ATCPT2(3,1) =
                SINTT1+TERM2(3) - COSTT1+TERM2(2)
                                                                     XDOT
                COSTT1 #TERM2(1)
                                                                     XDOT
A^TCPT2(3,2) =
ATCPT2(3+3) = -SINTT1+TERM2(1)
                                                                     XDOT
HDOT(1) = WO(3) + H(2) = WO(2) + H(3)
                                                                     XDOT
          + (-TERM1(3) +FO(2) + TERM1(2) +FO(3))/TOTMAS
                                                                     TOGX
#+ (ATCPT2(1.1) #F1(1) +ATCPT2(1.2) #F1(2) +ATCPT2(1.3) #F1(3))/TOTMAS
                                                                     XDOT
                                                                     XDOT
** TOEF(1) * TIEF(1)
HOOT(2) = -WO(3) + WO(1) + WO(1) + WO(3)
                                                                     XDOT
          +(TERM^{1}(3)+FO(1) = TERM^{1}(1)+FO(3))/TOTMAS
                                                                     XDOT
*+ (ATCPT2(2,1) *F1(1) +ATCPT2(2,2) *F1(2) +ATCPT2(2,3) *F1(3))/TOTMAS
                                                                     XDOT
*+ TOEF(2) + COSTT1*T1EF(2) - SINTT1*T1EF(3)
                                                                     XDOT
HDOT(3) =
            WO(2) #H(1) = WO(1) #H(2)
                                                                     XDOT
          + (-TERM1(2) +FO(1) + TERM1(1) +FO(2))/TOTMAS
                                                                     XDOT
#+(ATCPT2(3:1)#F1(1)+ATCPT2(3:2)#F1(2)+ATCPT2(3:3)#F1(3))/TOTMAS
                                                                     XDOT
*+ TOEF(3) + SINTT1*T1EF(2) + COSTT1*T1EF(3)
                                                                     XD01
 CALCULATE THE TORQUE BETWEEN BODY 0 AND BODY 1. (CONTROL FRICTION) XDOT
 CALL TORKO1
                                                                     XDOT
HlpDOT(1) = -W1(2) + HlpRIM(3) + W1(3) + HlpRIM(2)
                                                                     XDOT
+RIDOT(2) # (=82MASS#EL2DOT(3)=B3MASS#(D13DOT(3)+EL3DOT(3))=
                                                                     XDOT
# B4MASS*(D14DOT(3)+EL4DOT(3)))=R1DOT(3)*(=B2MASS*EL2DOT(2)=
                                                                     XDOT
# B3MASS#(D13DOT(2)+EL3DOT(2))=B4MASS#(D14DOT(2)+EL4DOT(2)))
                                                                     XDOT
**AJ1(2)*(~FO(2)*SINTT1/TOTMAS*FO(3)*COSTT1/TOTMAS)
                                                                     XDOT
*+AJ1(3)*( FO(2)*COSTT1/TOTMAS+FO(3)*SINTT1/TOTMAS)
                                                                     XDOT
#+AJ1(3)#F1(2)/TOTMAS=AJ1(2)#F1(3)/TOTMAS+T1EF(1)+To1
                                                                     XDOT
 CALCULATE THE TORQUE BETWEEN BODY 1 AND BODY 3. (CONTROL FRICTION) XDOT
 CALL TORK13(T13,CP1,CP2,THETA3,OMEGA3)
                                                                     XDOT
 G3DDTm=S3(2) + (W1(3):#H3PRIM(1) -W1(1) #H3PRIM(3)) -S3(3) #(W1(1) #H3PRIMXDOT
#(2)=W1(2)#H3PRiM(1))+B3MASS&S3(2)#(EL3DOT(3)&R3D0[(1)=EL3DOT(1)&R3XDOT
#DOT(3))+B3MASS*S3(3)*(EL3DOT(1)*R3DOT(2)-EL3DOT(2)*R3DOT(1))*
                                                                     XDOT
*(B3MASS/TOTMAS) +S3(2) + (EL3(3) + (FO(1) +F1(1)) -EL3(1) + (-F0(2) +SINTT1+XDOT
#FO(3) #COSTT1+F1(3))) # (B3MASS/TOTMAS) #S3(3) # (EL3(1) # (FD(2) #COSTT1+ XDOT
*FO(3)*SINTT1+F1(2)}*EL3(2)*(FO(1)+F1(1)))+T13
                                                                     XDOT
CALCULATE THE TORQUE BETWEEN BODY 1 AND BODY 4. (CONTROL FRICTION) XDOT
 CALL TORK14(T)4.CP3.CP2.THETA4.OMEGA4)
                                                                     XDOT
 G4DOT==S4(2)+(W1(3)+H4PRIM(1)+W1(1)+H4PRIM(3))+S4(3)+(W1(1)+H4PRIMXDOT
*(2) -W1(2) *H4PRIM(1)) +84MASS#S4(2) *(EL4DOT(3) *R4DOT(1) -EL4DOT(1) *R4XDOT
*DOT(3))+B4MASS*S4(3)*(EL4DOT(1)*R4DOT(2)*EL4DOT(2)*R4DOT(1))*
                                                                     XDOT
#(B4MASS/TOTMAS)#S4(2)#(EL4(3)#(FO(1)+F1(1))=EL4(1)#(=FO(2)#SINTT1+xDOT
#FO(3) #COSTT1+F1(3) }--(B4MASS/TOTMAS) #$4(3) #(EL4(1) #(FO(2) #COSTT1+ XDOT
#FO(3)#SINTT1+F1(2)}=EL4(2)#(FO(1)+F1(1)))+T14
                                                                     XDOT
                                                                     XDOT
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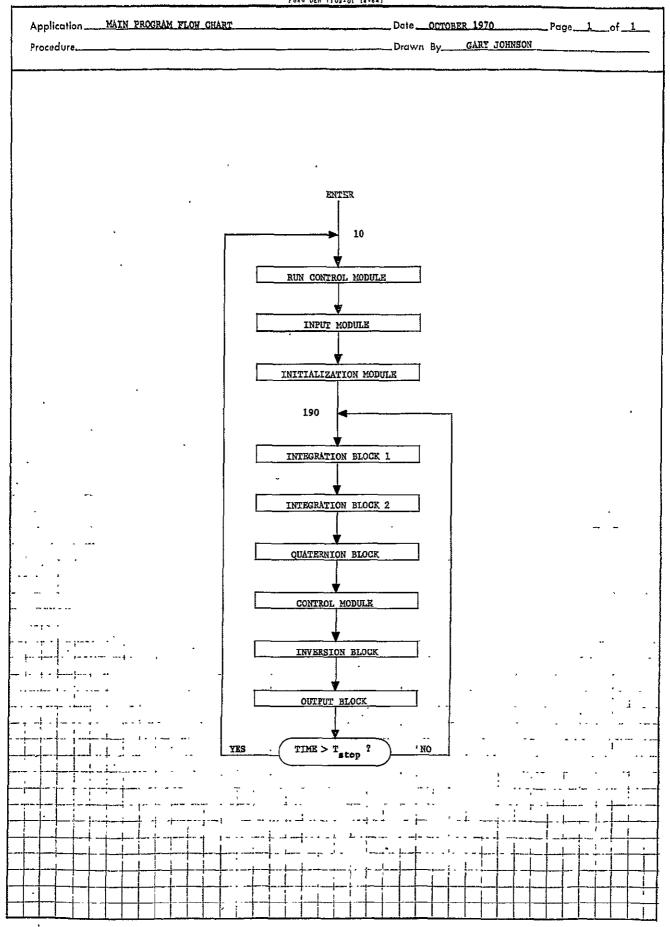
C

END.

C = 60

## APPENDIX D, PROGRAM FLOW CHARTS

## FLOW CHART & BLOCK CLAGRAM



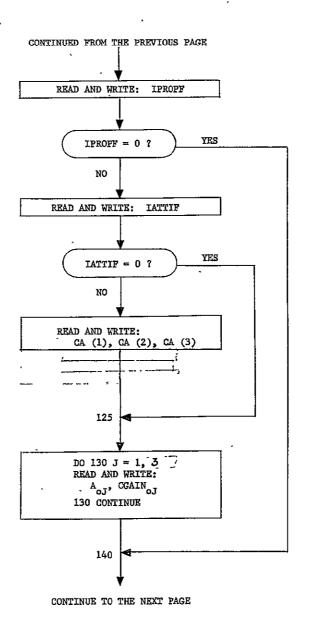
## FLOW CHART & BLOCK DIAGRAM

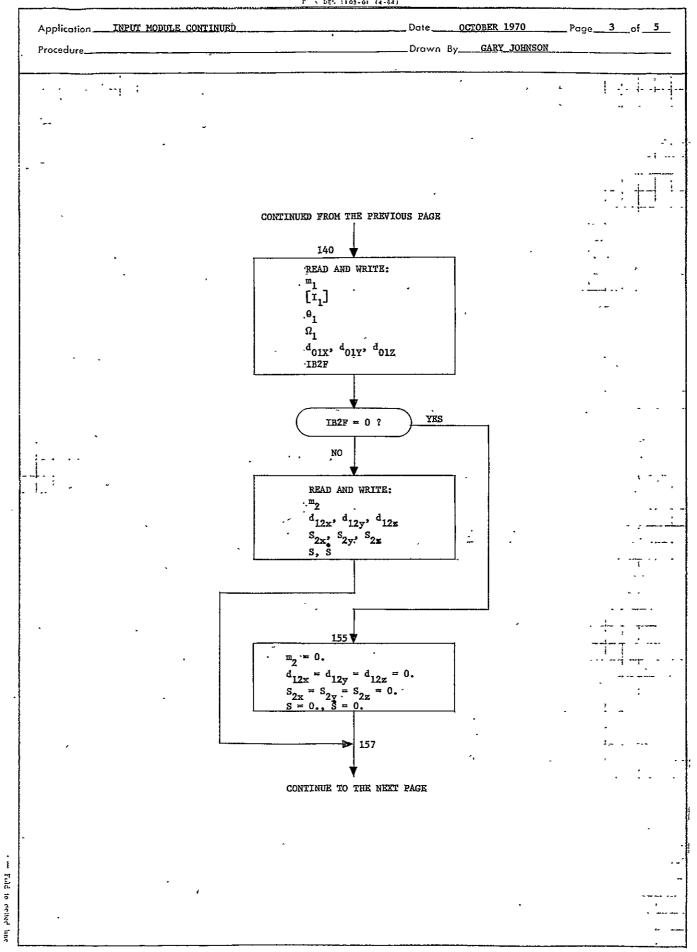
RUN CONTROL MODULE Application \_ Date OCTOBER 1970 Drawn By GARY JOHNSON Procedure\_ ENTER NCHECK = 0 READ AND WRITE: NDECK NCHECK = NCHECK + 1 NO NDECK ≥ NCHECK ? YES STOP CONTINUE TO THE INPUT MODULE

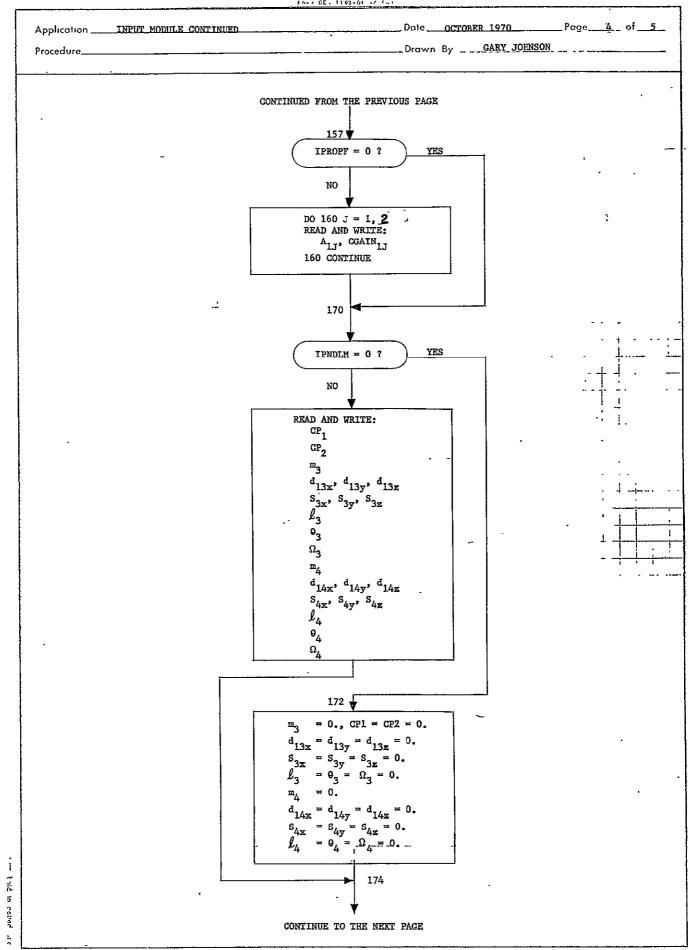
# FLOW CHART & BLOCK DIAGRAM

Application INPUT MODULE	Date OCTOBER 1970 Page 1 of 5
Procedure	Drawn ByGARY_JOHNSON
•	
	enter
	· · · · · · · · · · · · · · · · · · ·
•	'GAIN(M) = 0M.=1,10 . WRITE: NCHECK
	READ AND WRITE: IPNDLM
	IPRINT
	T <sub>start</sub> , T <sub>stop</sub> , At
	[I, B <sub>o</sub> ] <sub>I</sub>
	wox, wox
	NUMCMG
	`
<del>.</del>	· · · · · · · · · · · · · · · · · · ·
•	NUMCMG = 0 ? YES
	NO ;
	NU V
	DO 110 J = 1, NUMCMG READ AND WRITE:
and the second s	IDOF (J)
	H <sub>W</sub> J
TOTAL MENSEL WITH A STATE OF THE STATE OF TH	[0, C <sub>J</sub> ]  IF (IDOF (1) .EO. 0) GO TO 110
	IF (IDOF (J) .EQ. 0) GO TO 110 READ AND WRITE:
	[11,]
material manager	
a manifest and a figure	
	· · · · • • • · · · · · · · · · · · · ·
	IF (IDOF- (J) .EQ. 1) GO TO 110 READ AND WRITE:
	110 CONTINUE
	120
	CONTINUE TO THE NEXT PAGE
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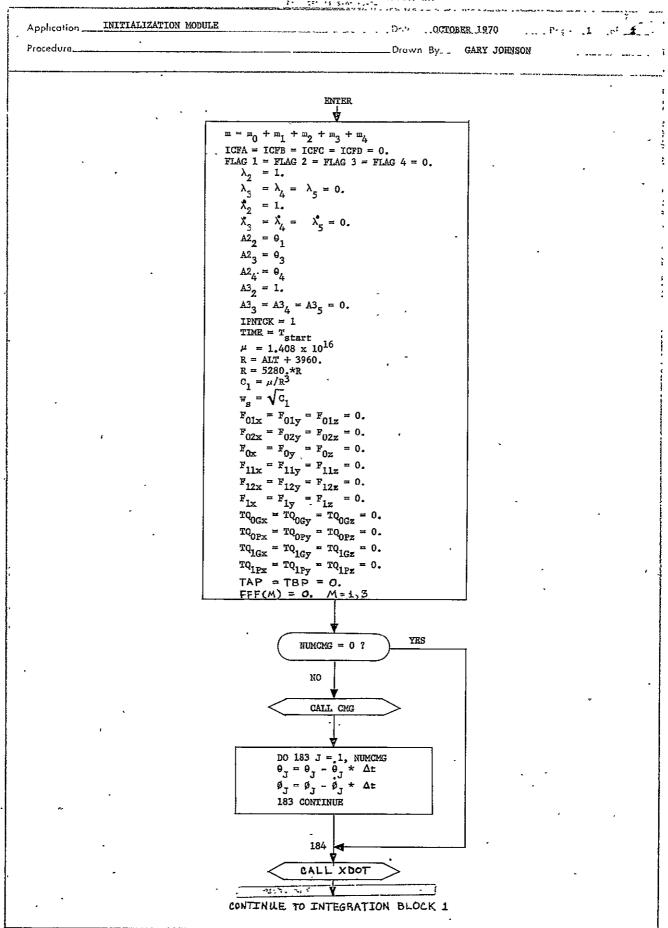
ApplicationINPUT MODULE CONTINUED	Date_	OCTOBE	R 1970		_Page_	<u>2·</u> of	<u>5</u>
Procedure	Drawr	Ву	_GARY_J	OHNSON	·		

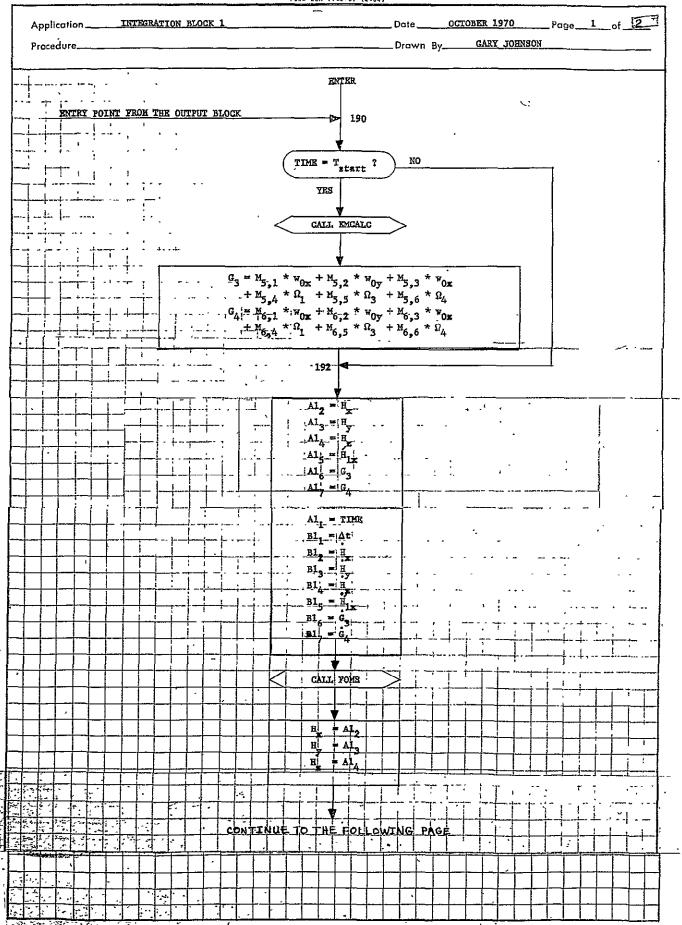






Apply offer INPUT MODULE CONTINUED \_\_Page\_\_5\_\_of\_\_5 \_\_\_\_\_Date\_\_\_\_\_OCTOBER 1970 \_\_\_\_\_Drawn By\_\_\_GARY\_JOHNSON Procedute\_\_\_\_ CONTINUED FROM THE PREVIOUS PAGE 174 READ AND WRITE: SP NGAIN NGAIN. = 0 ? NO DO 175 J = 1, NGAIN READ AND WRITE:  $_{\mathtt{GAIN}_{\mathtt{J}}}$ 175 CONTINUE 176 READ AND WRITE: **IGRAVF** IDOCK جاء IDOCK = 0 ? NO READ AND WRITE: T<sub>dock</sub>  $DT_{\min} = T_{\text{dock}} - \Delta t/10.$   $DT_{\max} = T_{\text{dock}} + \Delta t/10.$ DCH<sub>min</sub> =  $T_{dock}$  - 1.1\*  $\Delta t$ DCH<sub>max</sub> =  $T_{dock}$  - 0.9\*  $\Delta t$ READ AND WRITE:  $[\underline{x}^{D}]$ DTI<sub>x</sub>, DTI<sub>y</sub>, DTI<sub>z</sub> DD<sub>01x</sub>, DD<sub>01y</sub>, DD<sub>01z</sub> 180 CONTINUE TO THE INITIALIZATION MODULE

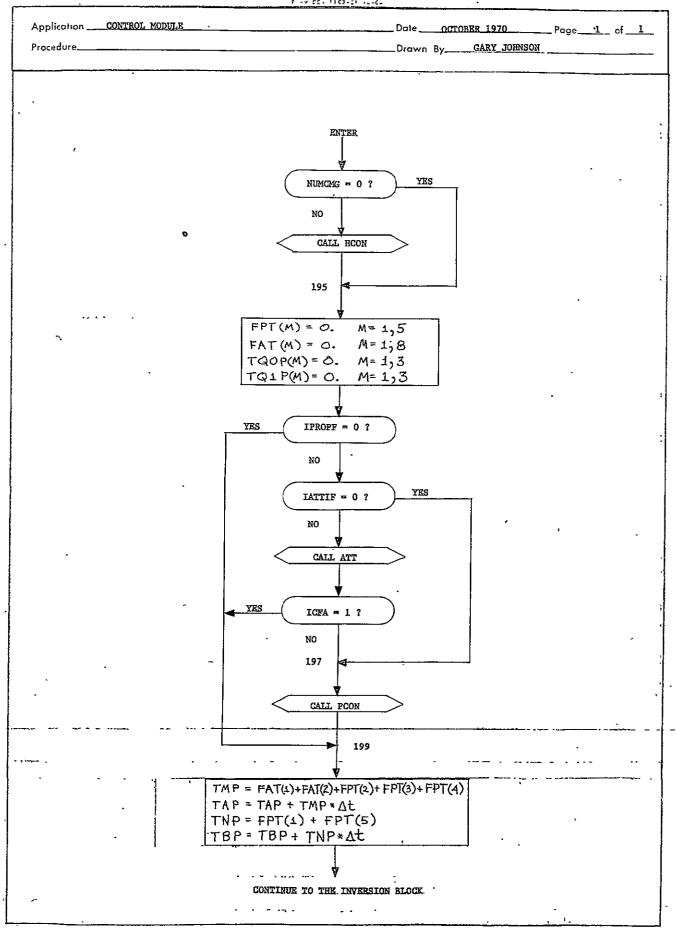




Application INTEGRATION BLOCK 1 CONTINUED \_Date\_OCTOBER\_1970\_\_Page\_2\_\_of\_2\_ Drawn By GARY JOHNSON Procedure... CONTINUED FROM THE PREVIOUS PAGE YES IDOCK = 0 NO (TIME < DCHmin ) OR (TIME > DCHmax) ? No  $H_x = H_x + DTI_x$ Hy = Hy + DTIy Hz = Hz + DTIz 193 H<sub>1x</sub> = A1<sub>5</sub> = A1<sub>6</sub> CONTINUE TO INTEGRATION BLOCK 2

Application	INTEGRATION BLOCK 2		Date	_ocre	BER 1970	Page_	J of
Procedure			Drawn	Ву	GARY JOHNSON		
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	,	enter					
		A2 <sub>1</sub> = TIME					
		$B2_{1} = \Delta t$	.				
		$B2_{2} = \theta_{1}$					
		$ B2_3 = \theta_3  B2_4 = \dot{\theta}_4 $					
: !		CALL FOMS		•			
		1.					•
	•	<b>V</b>	<del></del>				
		$\theta_1 = \frac{A2}{2}$ $\theta_3 = A2_3$					*
		$\theta_{\lambda} = A2_{\Delta}$					
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		CONTINUE TO THE QUATER	NION BLOCK				
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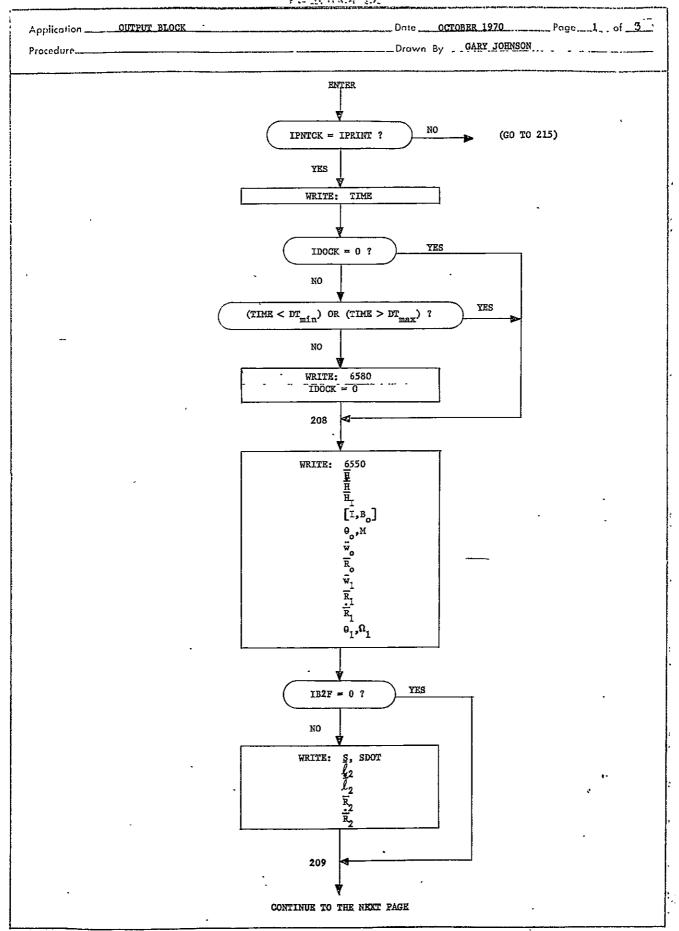
Application QUATE	KRNION BLOCK	DateDrawn_By		age 1 of 1
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	$[Q] = \frac{1}{2} \begin{bmatrix} 0 & -w_{0x} & -w_{0x} \\ w_{0x} & 0 & w_{0y} & w_{0x} \\ w_{0y} & w_{0y} & w_{0y} \end{bmatrix}$	W <sub>0</sub> y = W <sub>0</sub> x W <sub>0</sub> y = W <sub>0</sub> y 0. W <sub>0</sub> x W <sub>0</sub> x 0.		
	$\begin{bmatrix} \ddot{x}_2 \\ \ddot{x}_3 \\ \ddot{x}_4 \\ \ddot{x}_5 \end{bmatrix} = \begin{bmatrix} Q \\ \lambda_2 \\ \lambda_3 \\ \lambda_4 \\ \lambda_5 \end{bmatrix}$	r 200	30	
	A3 <sub>1</sub> = TIME  B3 <sub>1</sub> = $\Delta$ t  B3 <sub>2</sub> = $\chi$ B3 <sub>3</sub> = $\chi$ 3			
	B3 <sub>4</sub> = X <sub>4</sub> B3 <sub>5</sub> = X <sub>5</sub>	· .		
	$\lambda_2 = A3_2$	FOMS	¬	1 - p
:	$\lambda_3 = A3_3$ $\lambda_4 = A3_4$ $\lambda_5 = A3_5$	;2 ;2 ,2		,
- ar a summi	$\lambda_2 = \lambda_2 / \mathbb{F}_{N}$ $\lambda_3 = \lambda_3 / \mathbb{F}_{N}$ $\lambda_4 = \lambda_4 / \mathbb{F}_{N}$	$\lambda_{3}^{2} + \lambda_{4}^{2} + \lambda_{5}^{2}$	. ,	
	$ \lambda_{5} = \lambda_{5}/Y_{N}  T_{1,1} = \lambda_{2} + \lambda_{2} + \lambda_{2} + \lambda_{3} = 2 * (\lambda_{1,3}) $ $ T_{1,2} = 2 * (\lambda_{1,3}) = 2 * (\lambda_{1,3}) = 2 * (\lambda_{1,3}) $	$\lambda_3^2 - \lambda_4^2 - \lambda_5^2$ $3^{\lambda_4} - \lambda_2^{\lambda_5}$ $3^{\lambda_5} + \lambda_2^{\lambda_4}$		
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	T <sub>3,2</sub> = 2 * (\lambda \tau \tau \tau \tau \tau \tau \tau \ta	J		
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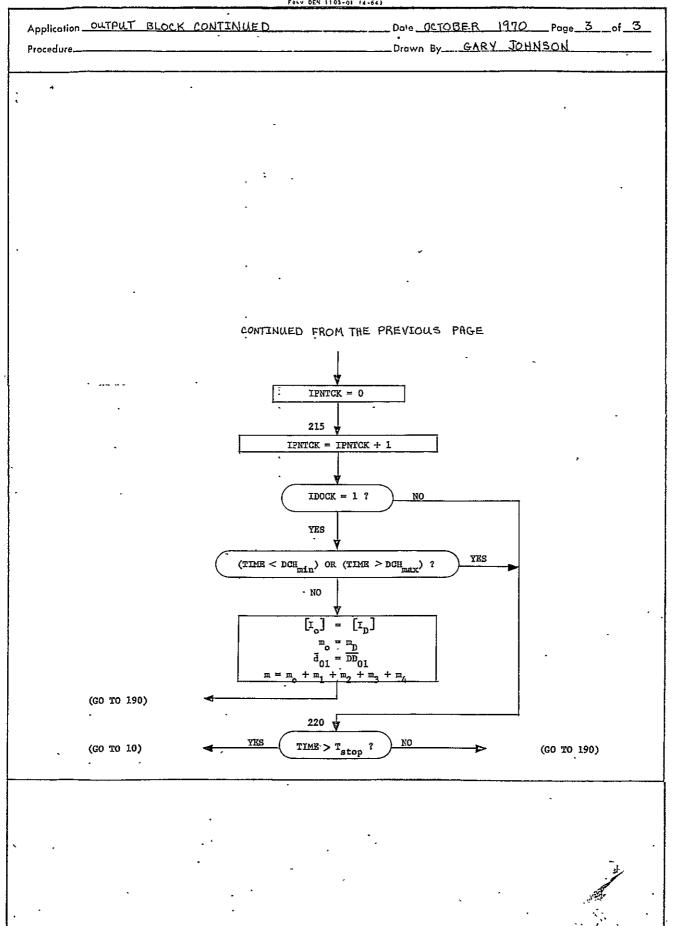
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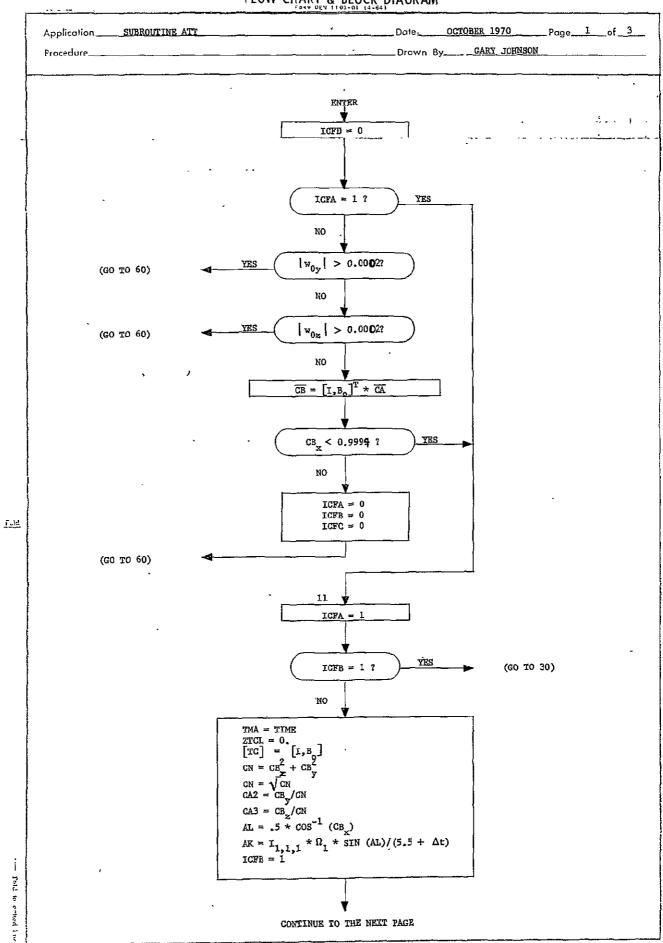
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	₩			
	IBNDTW = 0 3	es		
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	$\overline{V} = \overline{H} - \overline{FFF}$			
	X <sub>1.7</sub> = V <sub>x</sub>			
	X <sub>2 7</sub> = V <sub>2</sub>		,	
	X <sub>3</sub> ,7 = V <sub>z</sub> x <sub>1</sub> = H			
	$X_{4,7} = H_{1x}$ $X_{5,7} = G_3$			
а.	$X_{6,7} = G_4$			
` .		_		
	CALL SYEQNS	,		
•	CALL STEUNS			
•	₩	·		
	w <sub>0x</sub> = X <sub>1,7</sub>			
	W <sub>0y</sub> = X <sub>2</sub> ,7 W <sub>0z</sub> = X <sub>3</sub> ,7			
	₩0z = X3,7			-
	$ \begin{array}{ccc} \Omega_1 &= X_4, 7 \\ \Omega_3 &= X_5, 7 \end{array} $			
•	$\Omega_4 = X_{6,7}$			
	•			
	202			
	$\overline{V} = \overline{H} - \overline{FFF}$			
•	X1,5 = V	•		
,	X2,5 = V X <sub>0</sub> = V	, , , , , ,		
	$X_{4,5} = X_{1x}$			
	1 4,5 1x ·		•	
	<b>∀</b> .	•		
<del>'</del> '	CALL SYEQUE		-	
···· ;	w <sub>0x</sub> = X <sub>1,5</sub>			
	W <sub>0v</sub> = X <sub>2.5</sub>			•
· · · · · · · · · · · · · · · · · · ·	' W <sub>Oz</sub> = X <sub>3.5</sub>			
[ / -	$ \Omega_{\mathbf{I}} = \mathbf{x}_{4,5} \\ \Omega_{\mathbf{q}} = 0. $			
., , , , , , , , , , , , , , , , , , ,	$\Omega_{h} = 0$			
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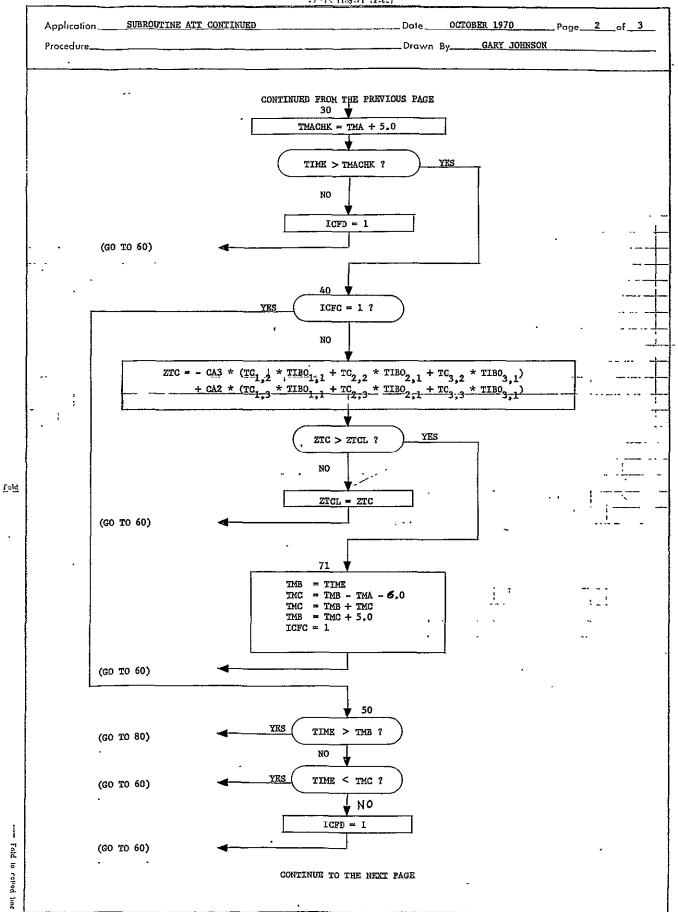
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Procedure			Drawn	Ву	GARY JOHNSON.		<del></del>
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		TIME = TIME	3 + Δt	] .			
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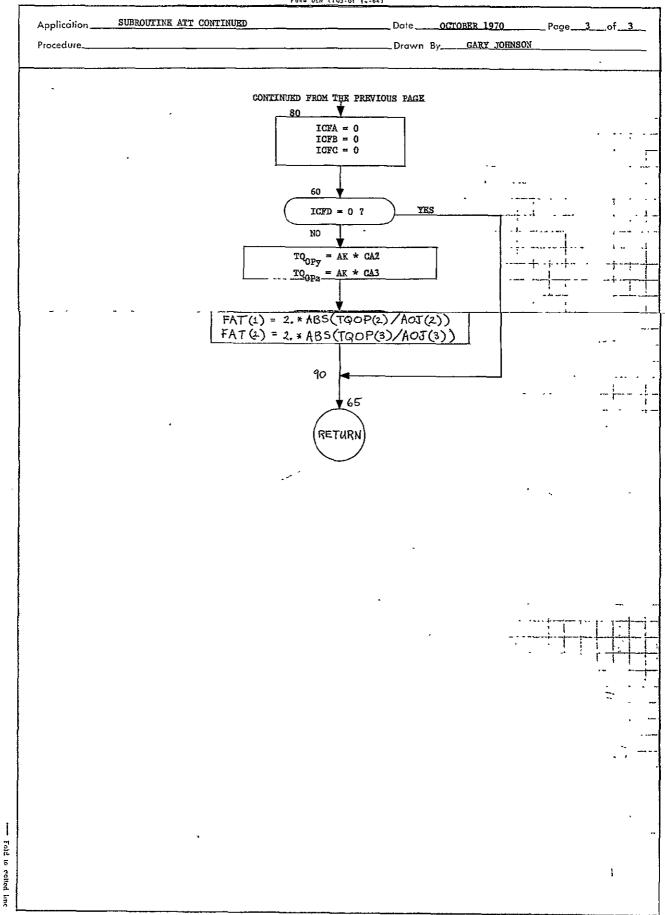


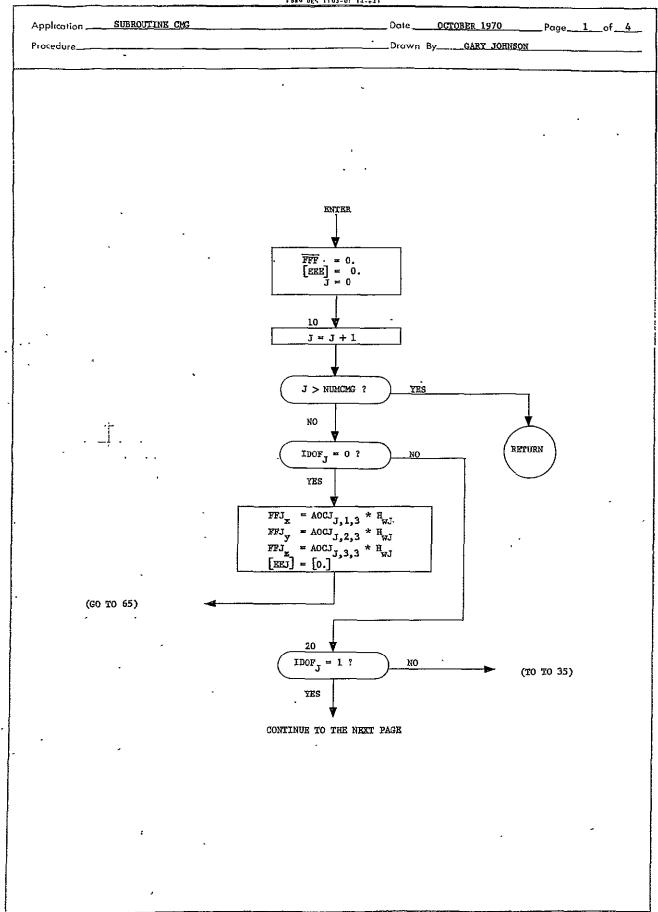
Application OUTPUT BLOCK CONTINUED	Date OCTOBER 1970 Page 2 of 2
Procedure	Drawn By GARY JOHNSON
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<u></u>	70770
IPNDLM = 0 ?	YES
NO A	
WRITE: $\vec{v}_3$	
· <del>/</del> <del>/</del> <del>/</del> <del>2</del> 3	•
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NUMCMG = 0	╼╌╌┩╼┼╼╀╼┼╼┼╼┼╸┼╶┼╴┼
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. NO	
DO 213 J = 1, NUME.	
$DO 213 3 = 12 NUMC.$ $WRITE: O_{7} > O_{4}$	-713-
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. WRITE! Du Da	
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Application	SUBROUTINE	CMG CONTINUED	 	Date	OCTOBER	1970	_Page	2_	of	4_
Procedure			 	Drawn	ByGAI	A TOHNRON		•		

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= C0<sub>J</sub> * AII<sub>J,1,2</sub> * 0<sub>J</sub> + S0<sub>J</sub> * AII<sub>J,3,2</sub> * 0<sub>J</sub> + S0<sub>J</sub>H<sub>WJ</sub>
= S0<sub>J</sub> * S0<sub>J</sub> * AII<sub>J,1,2</sub> * 0<sub>J</sub> + C0<sub>J</sub> * AII<sub>J,2,2</sub> * 0<sub>J</sub> - S0<sub>J</sub> * C0<sub>J</sub> * AII<sub>J,3,2</sub> * 0<sub>J</sub>
= S0<sub>J</sub> * C0<sub>J</sub> * AII<sub>J,1,2</sub> * 0<sub>J</sub> + S0<sub>J</sub> * AII<sub>J,2,2</sub> * 0<sub>J</sub>
+ C0<sub>J</sub> * C0<sub>J</sub> * AII<sub>J,3,2</sub> * 0<sub>J</sub> + H<sub>WJ</sub> * C0<sub>J</sub>
= [0 c ] * TEMP12
TEMP12
TEMP12
                         = [0,C_{J}] * \overline{TEMP12}
TEMP13_{1,3} = C\theta_J * AOCJ_{J,3,1} + S\theta_J * S\theta_J * AOCJ_{J,3,2} - S\theta_J * C\theta_J * AOCJ_{J,3,3}
TEMP13_{2,1} = CØ_J * AOCJ_{1,1,2} + SØ_J * AOCJ_{1,1,3}
TRMP13_{2,2} = CØ_J * AOCJ_{J,2,2} + SØ_J * AOCJ_{J,2,3}
TEMP13<sub>2,3</sub> = CØ_J * AOCJ_{J,3,2} + SØ_J * AOCJ_{J,3,3}
TEMP13_{3,1} = S\theta_J * AOCJ_{J,1,1} - S\emptyset_J * C\theta_J * AOCJ_{J,1,2} + C\emptyset_J * C\theta_J * AOCJ_{J,1,3}
TEMP13<sub>3,2</sub> = s\theta_J * AOCJ_{J,2,1} - s\theta_J * C\theta_J * AOCJ_{J,2,2} + C\theta_J * C\theta_J & AOCJ_{J,2,3}
 \begin{array}{l} \text{TEMP13}_{3,3} = \text{SO}_{J} * \text{AOCJ}_{J,3,1} - \text{SO}_{J} * \text{CO}_{J} * \text{AOCJ}_{J,3,2} + \text{CO}_{J} * \text{CO}_{J} * \text{AOCJ}_{J,3,3} \\ \text{[TEMP14]} = \begin{bmatrix} \text{II}_{J} \end{bmatrix} * \begin{bmatrix} \text{TEMP13}_{J,1} + \text{SO}_{J} * \text{TEMP14}_{J,1} + \text{SO}_{J} * \text{TEMP14}_{J,1} \\ \text{TEMP15}_{J,1} & \text{CO}_{J} * \text{TEMP14}_{J,1} + \text{SO}_{J} * \text{TEMP14}_{J,1} \\ \end{array} 
TEMP15_{1,2} = C\theta_J * TEMP14_{1,2} + S\theta_J * TEMP14_{3,2}
TEMP15_{1,3} = G\theta_J * TEMP14_{1,3} + S\theta_J * TEMP14_{3,3}
\text{TEMP15}_{2,1} = \text{SØ}_{J} * \text{SØ}_{J} * \text{TEMP14}_{1,1} + \text{CØ}_{J} * \text{TEMP14}_{2,1} - \text{SØ}_{J} * \text{CØ}_{J} * \text{TEMP14}_{3,1}
\text{TEMP15}_{2,2} = \text{sØ}_{\text{J}} * \text{sØ}_{\text{J}} * \text{TEMP14}_{1,2} + \text{cØ}_{\text{J}} * \text{TEMP14}_{2,2} - \text{sØ}_{\text{J}} * \text{cO}_{\text{J}} * \text{TEMP14}_{3,2}
\text{TEMP15}_{2,3} = \text{SØ}_{J} * \text{SØ}_{J} * \text{TEMP14}_{1,3} + \text{CØ}_{J} * \text{TEMP14}_{2,3} - \text{SØ}_{J} * \text{CO}_{J} * \text{TEMP14}_{3,3}
\mathsf{TRMP15}_{3,1} = - \ \mathsf{S0}_{\mathtt{J}} \times \mathsf{C0}_{\mathtt{J}} \times \mathsf{TEMP14}_{1,1} + \mathsf{S0}_{\mathtt{J}} \times \mathsf{TEMP14}_{2,1} + \mathsf{C0}_{\mathtt{J}} \times \mathsf{C0}_{\mathtt{J}} \times \mathsf{TEMP14}_{3,1}
\text{TEMP15}_{3,2} = -\text{SØ}_{\mathtt{J}} * \text{CØ}_{\mathtt{J}} * \text{TEMP14}_{1,2} + \text{SØ}_{\mathtt{J}} * \text{TEMP14}_{2,2} + \text{CØ}_{\mathtt{J}} * \text{CØ}_{\mathtt{J}} * \text{TEMP14}_{3,2}
TEMP15_{3,3} = -S\theta_J * C\theta_J * TEMP14_{1,3} + S\theta_J * TEMP14_{2,3} + C\theta_J * C\theta_J * TEMP14_{3,3}
[EEJ] = [0, c_J] * [TEMP15]
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(GO TO 60)

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Application SUBROUTINE CMG CONTINUED
                                                                                                                                                                                                                                             OCTOBER 1970
                                                                                                                                                                                                                                                                                                               Page___3_ of
                                                                                                                                                                                                                                                                GARY JOHNSON
                                                                                                                                                                                                                     Drawn By_
Procedure.
                                                                                                                                 CONTINUED FROM THE PREVIOUS PAGE
                                       TEMP1_
                                                                   = AIO<sub>J,1,1</sub> * Ö<sub>J</sub>
                                                                   = C_{J}^{0} + A_{IO}_{J,2,1} + 0_{J} - S_{J}^{0} + A_{IO}_{J,3,1} + 0_{J}^{0}
                                      TEMP1
                                                                   = s \emptyset_J * AiO_{J,2,1} * \emptyset_J + c \emptyset_J * AiO_{J,3,1} * \emptyset_J
                                                                   = C\theta_J * \left[ AII_{J,1,1} * C\theta_J * \mathring{\theta}_J + AII_{J,1,2} * \mathring{\theta}_J + AII_{J,1,3} * S\theta_J * \mathring{\theta}_J \right]
                                       TEMP2
                                                                  = C6<sub>J</sub> * [AII<sub>J</sub>,1,1 * C6<sub>J</sub> * $\vartheta_J + AII<sub>J</sub>,1,2 * $\vartheta_J + AII<sub>J</sub>,1,3 * S6<sub>J</sub> * $\vartheta_J \\
+ S6<sub>J</sub> * [AII<sub>J</sub>,3,1 * C6<sub>J</sub> * $\vartheta_J + AII<sub>J</sub>,3,2 * $\vartheta_J + AII<sub>J</sub>,3,3 * S6<sub>J</sub> * $\vartheta_J \\
= S6<sub>J</sub> * S9<sub>J</sub> * [AII<sub>J</sub>,1,1 * C6<sub>J</sub> * $\vartheta_J + AII<sub>J</sub>,1,2 * $\vartheta_J + AII<sub>J</sub>,1,3 * S6<sub>J</sub> * $\vartheta_J \\
+ C6<sub>J</sub> * [AII<sub>J</sub>,2,1 * C6<sub>J</sub> * $\vartheta_J + AII<sub>J</sub>,2,2 * $\vartheta_J + AII<sub>J</sub>,3,3 * S6<sub>J</sub> * $\vartheta_J \\
= S6<sub>J</sub> * C6<sub>J</sub> * [AII<sub>J</sub>,3,1 * C6<sub>J</sub> * $\vartheta_J + AII<sub>J</sub>,3,2 * $\vartheta_J + AII<sub>J</sub>,1,3 * S6<sub>J</sub> * $\vartheta_J \\
= S6<sub>J</sub> * C6<sub>J</sub> * [AII<sub>J</sub>,1,1 * C6<sub>J</sub> * $\vartheta_J + AII<sub>J</sub>,2,2 * $\vartheta_J + AII<sub>J</sub>,2,3 * S6<sub>J</sub> * $\vartheta_J \\
= S6<sub>J</sub> * C6<sub>J</sub> * [AII<sub>J</sub>,3,1 * C6<sub>J</sub> * $\vartheta_J + AII<sub>J</sub>,3,2 * $\vartheta_J + AII<sub>J</sub>,3,3 * S6<sub>J</sub> * $\vartheta_J \\
= H_ * $S6_J * $\vartheta_J \\
= H_ * $S6_J * $\vartheta_J \\
= H_ * $S6_J * $\vartheta_J \\
= S6_J * $\vartheta_J + AII<sub>J</sub>,3,3 * S6_J * $\vartheta_J \\
= S6_J * $\vartheta_J + AII<sub>J</sub>,3,3 * S6_J * $\vartheta_J \\
= S6_J * $\vartheta_J + AII<sub>J</sub>,3,3 * S6_J * $\vartheta_J \\
= S6_J * $\vartheta_J + AII<sub>J</sub>,3,3 * S6_J * $\vartheta_J \\
= S6_J * $\vartheta_J + AII<sub>J</sub>,3,3 * S6_J * $\vartheta_J 
                                      TEMP2
                                                                    = H<sub>wJ</sub> * S9<sub>J</sub>
                                       TEMP3_
                                      темр3
                                                                   = "H" * C61 * Z01
                                                                  = H<sub>wJ</sub>. * C9<sub>J</sub> * C9<sub>J</sub>
                                       TEMP3
                                                                   = TEMP1 + TEMP2 + TEMP3
                                                                   = [0,C] * TEMP4
                                       FFJ
                                      TEMP5_{1,1} = AOCI_{J,1,1}
                                      TEMP5_{1,2} = AOCJ_{J,2,1}
                                      TEMP5_{1,3} = AOCJ_{1,3,1}
                                      TEMP5_{2,1} = CØ_J * AOCJ_{J,1,2} + SØ_J * AOCJ_{J,1,3}
                                      TEMP5_{2,2} = C0_J * AOCJ_{J,2,2} + S0_J * AOCJ_{J,2,3}
                                      TEMP5_{2,3} = CØ_J * AOCJ_{J,3,2} + SØ_J * AOCJ_{J,3,3}
                                      TRMP5_{3,1} = -Sp_J * AOCJ_{J,1,2} + Cp_J * AOCJ_{J,1,3}
                                      TEMP5_{3,2} = -.50_J * AOCJ_{1,2,2} + C0_J * AOCJ_{1,2,3}
                                      TRMP53,3 = -\text{SØ}_J * \text{AOCJ}_{J,3,2} + \text{CØ}_J * \text{AOCJ}_{J,3,3}
TRMP6 = [\text{IO}_J] * \overline{\text{TRMP5}}
                                      TEMP71,1 = TEMP61,1
                                      TEMP71,2 = TEMP61,2
                                    · TEMP71,3 = TEMP61.3
                                      TEMP7_{2,1} = C0_J * TEMP6_{2,1} - S0_J * TEMP6_{3,1}
                                      TEMP7_{2,2} = C0_J * TEMP6_{2,2} - S0_J * TEMP6_{3,2}
                                      TEMP72,3 = CØJ * TEMP62,3 - SØJ * TEMP63,3
                                   ^{1}\text{TKMP7}_{3,1} = \text{SØ}_{J} * \text{TKMP6}_{2,1} + \text{CØ}_{J} * \text{TKMP6}_{3,1}
                                      TEMP7_{3,2} = SØ_J * TEMP6_{2,2} + CØ_J * TEMP6_{3,2}
                                      TEMP7_{3,3} = S0_{J} * TEMP6_{2,3} + C0_{J} * TEMP6_{3,3}
                                      \mathsf{TRMP8}_{1,1} = \mathsf{CO}_1 * \mathsf{AOCJ}_{1,1,1} + \mathsf{SØ}_1 * \mathsf{SO}_1 * \mathsf{AOCJ}_{1,1,2} - \mathsf{SO}_1 * \mathsf{CØ}_1 * \mathsf{AOCJ}_{1,1,3}
                                      \underline{\mathsf{TEMP8}}_{1,2} = \underline{\mathsf{CO}}_{\mathtt{J}} * \underline{\mathsf{AOCJ}}_{\mathtt{J},2,1} + \underline{\mathsf{SO}}_{\mathtt{J}} * \underline{\mathsf{SO}}_{\mathtt{J}} * \underline{\mathsf{AOCJ}}_{\mathtt{J},2,2} - \underline{\mathsf{SO}}_{\mathtt{J}} * \underline{\mathsf{CO}}_{\mathtt{J}} * \underline{\mathsf{AOCJ}}_{\mathtt{J},2,3}
                                   TEHR81,3 = CO, * AOCUJ,3,1 + SØ, * SO, * AOCUJ,3,2 ~ SO, * CØ, * AOCUJ,3,3
                                      TEMP8_{2,1} = CP_{J_1} * AOCI_{J_2J_2} + SP_{J_1} * AOCI_{J_2J_2}
                                      TEMP8 _{2} = C0_{J} * A0CJ_{J,2,2} + 80_{J} * A0CJ_{J,2,3}
                                       TEMP8_{2,3} = Cp_{J} * AOCJ_{J,3,2} + 80_{J} * AOCJ_{J,3,3}
                                                                  = 80 \downarrow * A0CJ<sub>J</sub>,1,1 - 80 \downarrow * C0 \downarrow * A0CJ<sub>J</sub>,1,2 + C0 \downarrow * C0 \downarrow * A0CJ<sub>J</sub>,1,3
                                      TRUES, = SO, * AOCJ, 2,1 - SO, * CO, * AOCJ, 2,2 + CO, * CO, * AOCJ, 2,3,3

TRUES, = SO, * AOCJ, 2,1 - SO, * CO, * AOCJ, 2,2 + CO, * CO, * AOCJ, 3,3,3
                                                                                                                                                CONTINUE TO THE NEXT PAGE
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CONTINUED FROM THE FREVIOUS PAGE   [TRE9] = [II] [TRE05]	Application _	SUBROUTINE CMG CONTINUED Date OCTOBER 1970 Page 4 of 4
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]	Procedure	Drawn ByGARY_JOHNSON
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		•
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		•
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		·
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		·
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]		
[TEMP9] = [II_J] [TEMP8]  TEMP101,1 = C9_J * TEMP91,1 + S0_J * TEMP9_3,1  TEMP101,2 = C9_J * TEMP91,2 + S0_J * TEMP9_3,2  TEMP101,3 = C9_J * TEMP91,3 + S0_J * TEMP9_3,3  TEMP102,1 = S0_J * S0_J * TEMP91,1 + C0_J * TEMP9_2,1 - S0_J * C0_J * TEMP9_3,1  TEMP102,2 = S0_J * S0_J * TEMP91,2 + C0_J * TEMP9_2,2 - S0_J * C0_J * TEMP9_3,2  TEMP102,3 = S0_J * S0_J * TEMP9_1,3 + C0_J * TEMP9_2,3 - S0_J * C0_J * TEMP9_3,3  TEMP103,1 = -S0_J * C0_J * TEMP9_1,4 + S0_J * TEMP9_2,1 + C0_J * C0_J * TEMP9_3,1  TEMP103,2 = -S0_J * C0_J * TEMP9_1,2 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,2  TEMP103,2 = -S0_J * C0_J * TEMP9_1,3 + S0_J * TEMP9_2,2 + C0_J * C0_J * TEMP9_3,3  [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]  [EEJ] = [TEMP7] + [TEMP10]	•	•
TEMP10 <sub>1,1</sub> = C9 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>1,3</sub> = C9 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,2</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,3</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,3</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>3,1</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,1</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,1</sub> TEMP10 <sub>3,2</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,2</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>3,3</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,3</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> [TEMP11] = [TEMP1] + [TEMP10]  [EEJ] = [D,C] * [TEMP1]  [EEJ] = [D,C] * [TEMP1]		CONTINUED FROM THE PREVIOUS PAGE
TEMP10 <sub>1,1</sub> = C9 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>1,3</sub> = C9 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,2</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,3</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,3</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>3,1</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,1</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,1</sub> TEMP10 <sub>3,2</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,2</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>3,3</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,3</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> [TEMP11] = [TEMP1] + [TEMP10]  [EEJ] = [D,C] * [TEMP1]  [EEJ] = [D,C] * [TEMP1]		· · · · 1
TEMP10 <sub>1,1</sub> = C9 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>1,3</sub> = C9 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,2</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,3</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,3</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>3,1</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,1</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,1</sub> TEMP10 <sub>3,2</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,2</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>3,3</sub> = -S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,3</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> [TEMP11] = [TEMP1] + [TEMP10]  [EEJ] = [D,C] * [TEMP1]  [EEJ] = [D,C] * [TEMP1]		
TEMP10 <sub>1,2</sub> = G0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>1,3</sub> = G0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,1</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,1</sub> TEMP10 <sub>2,2</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>2,3</sub> = S0 <sub>3</sub> * S0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + C0 <sub>3</sub> * TEMP9 <sub>2,3</sub> - S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>3,1</sub> = S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,1</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,1</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,1</sub> TEMP10 <sub>3,2</sub> = S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,2</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>3,3</sub> = S0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>3</sub> * TEMP9 <sub>2,3</sub> + C0 <sub>3</sub> * C0 <sub>3</sub> * TEMP9 <sub>3,3</sub> [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [C,C] * [TEMP11]		
TEMP10 <sub>1,3</sub> = C0 <sub>J</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>J</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>2,1</sub> = S0 <sub>J</sub> * S0 <sub>J</sub> * TEMP9 <sub>1,1</sub> + C0 <sub>J</sub> * TEMP9 <sub>2,1</sub> - S0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>3,1</sub> TEMP10 <sub>2,2</sub> = S0 <sub>J</sub> * S0 <sub>J</sub> * TEMP9 <sub>1,2</sub> + C0 <sub>J</sub> * TEMP9 <sub>2,2</sub> - S0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>2,3</sub> = S0 <sub>J</sub> * S0 <sub>J</sub> * TEMP9 <sub>1,3</sub> + C0 <sub>J</sub> * TEMP9 <sub>2,3</sub> - S0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>3,3</sub> TEMP10 <sub>3,1</sub> = -S0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>1,1</sub> + S0 <sub>J</sub> * TEMP9 <sub>2,1</sub> + C0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>3,1</sub> TEMP10 <sub>3,2</sub> = -S0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>1,2</sub> + S0 <sub>J</sub> * TEMP9 <sub>2,2</sub> + C0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>3,2</sub> TEMP10 <sub>3,3</sub> = -S0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>1,3</sub> + S0 <sub>J</sub> * TEMP9 <sub>2,3</sub> + C0 <sub>J</sub> * C0 <sub>J</sub> * TEMP9 <sub>3,3</sub> [TEMP11] = [TEMP7] + [TEMP10] $ 0_J = 0_J + 0_J * \Delta t  0_J = 0_J * 0_J * \Delta t  0_J * 0_J * 0_J * 0_J * \Delta t  0_J * 0_J * 0_J * 0_J * 0_J * \Delta t  0_J * 0_$		TEMP101,1 = C9
TEMP10 <sub>2,1</sub> = $S\theta_J$ * $S\theta_J$ * TEMP9 <sub>1,1</sub> + $C\theta_J$ * TEMP9 <sub>2,1</sub> - $S\theta_J$ * $C\theta_J$ * TEMP9 <sub>3,1</sub> TEMP10 <sub>2,2</sub> = $S\theta_J$ * $S\theta_J$ * TEMP9 <sub>1,2</sub> + $C\theta_J$ * TEMP9 <sub>2,2</sub> - $S\theta_J$ * $C\theta_J$ * TEMP9 <sub>3,2</sub> TEMP10 <sub>2,3</sub> = $S\theta_J$ * $S\theta_J$ * TEMP9 <sub>1,3</sub> + $C\theta_J$ * TEMP9 <sub>2,3</sub> - $S\theta_J$ * $C\theta_J$ * TEMP9 <sub>3,3</sub> TEMP10 <sub>3,1</sub> = $S\theta_J$ * $C\theta_J$ * TEMP9 <sub>1,1</sub> + $S\theta_J$ * TEMP9 <sub>2,1</sub> + $C\theta_J$ * $C\theta_J$ * TEMP9 <sub>3,1</sub> TEMP10 <sub>3,2</sub> = $S\theta_J$ * $C\theta_J$ * TEMP9 <sub>1,2</sub> + $S\theta_J$ * TEMP9 <sub>2,2</sub> + $C\theta_J$ * $C\theta_J$ * TEMP9 <sub>3,2</sub> TEMP10 <sub>3,3</sub> = $S\theta_J$ * $C\theta_J$ * TEMP9 <sub>1,3</sub> + $S\theta_J$ * TEMP9 <sub>2,3</sub> + $C\theta_J$ * $C\theta_J$ * TEMP9 <sub>3,3</sub> [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = $[0,C_J]$ * [TEMP11]		TEMP101,2 Gd * TEMP91,2 T 50 J * TEMP93,2
$ \begin{array}{c} \text{TEMP10}_{2,2} = \text{SØ}_J * \text{SØ}_J * \text{TEMP9}_{1,2} + \text{CØ}_J * \text{TEMP9}_{2,2} - \text{SØ}_J * \text{CØ}_J * \text{TEMP9}_{3,3} \\ \text{TEMP10}_{2,3} = \text{SØ}_J * \text{SØ}_J * \text{TEMP9}_{1,3} + \text{CØ}_J * \text{TEMP9}_{2,3} - \text{SØ}_J * \text{CØ}_J * \text{TEMP9}_{3,3} \\ \text{TEMP10}_{3,1} = -\text{SØ}_J * \text{CØ}_J * \text{TEMP9}_{1,1} + \text{SØ}_J * \text{TEMP9}_{2,1} + \text{CØ}_J * \text{CØ}_J * \text{TEMP9}_{3,1} \\ \text{TEMP10}_{3,2} = -\text{SØ}_J * \text{CØ}_J * \text{TEMP9}_{1,2} + \text{SØ}_J * \text{TEMP9}_{2,2} + \text{CØ}_J * \text{CØ}_J * \text{TEMP9}_{3,2} \\ \text{TEMP10}_{3,3} = -\text{SØ}_J * \text{CØ}_J * \text{TEMP9}_{1,3} + \text{SØ}_J * \text{TEMP9}_{2,3} + \text{CØ}_J * \text{CØ}_J * \text{TEMP9}_{3,3} \\ \text{TEMP11} = \begin{bmatrix} \text{TEMP7} \end{bmatrix} + \begin{bmatrix} \text{TEMP10} \end{bmatrix} \\ \text{EEJ} \end{bmatrix} = \begin{bmatrix} \text{TEMP7} \end{bmatrix} + \begin{bmatrix} \text{TEMP11} \end{bmatrix} \\ \text{FFFF} = \frac{\text{FFF}}{\text{FFF}} + \frac{\text{FFJ}}{\text{FFJ}}} \\ \text{EEE} \end{bmatrix} = \begin{bmatrix} \text{EEE} \end{bmatrix} + \begin{bmatrix} \text{EEJ} \end{bmatrix} \\ \text{EEE} \end{bmatrix} = \begin{bmatrix} \text{EEE} \end{bmatrix} + \begin{bmatrix} \text{EEJ} \end{bmatrix} \end{array}$	-	TEMP10 = SØ * SO * TEMP9 + CØ * TEMP9 = SØ * CO * TEMP9
TEMP10 <sub>2,3</sub> = $S\theta_J$ * $S\theta_J$ * $TEMP9_{1,3}$ + $C\theta_J$ * $TEMP9_{2,3}$ - $S\theta_J$ * $C\theta_J$ * $TEMP9_{3,3}$ TEMP10 <sub>3,1</sub> = $S\theta_J$ * $C\theta_J$ * $TEMP9_{1,1}$ + $S\theta_J$ * $TEMP9_{2,1}$ + $C\theta_J$ * $C\theta_J$ * $TEMP9_{3,1}$ TEMP10 <sub>3,2</sub> = $S\theta_J$ * $C\theta_J$ * $TEMP9_{1,2}$ + $S\theta_J$ * $TEMP9_{2,2}$ + $C\theta_J$ * $C\theta_J$ * $TEMP9_{3,2}$ TEMP10 <sub>3,3</sub> = $S\theta_J$ * $C\theta_J$ * $TEMP9_{1,3}$ + $S\theta_J$ * $TEMP9_{2,3}$ + $C\theta_J$ * $TEMP9_{3,3}$ [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = $[O,C_J]$ * [TEMP11] $ \begin{array}{c} \theta_J = \theta_J + \hat{\theta}_J * \Delta x \\ \theta_J = \theta + \hat{\theta}_J * \Delta x \end{array} $ $ \begin{array}{c} \theta_J = \theta_J + \hat{\theta}_J * \Delta x \\ \theta_J = \theta + \hat{\theta}_J * \Delta x \end{array} $ $ \begin{array}{c} \theta_J = \theta_J + \hat{\theta}_J * \Delta x \\ \theta_J = \theta_J + \hat{\theta}_J * \Delta x \end{array} $ $ \begin{array}{c} \theta_J = \theta_J + \hat{\theta}_J * \Delta x \\ \theta_J = \theta_J + \hat{\theta}_J * \Delta x \end{array} $		7,1
TEMP10 <sub>3,1</sub> = $-80_J$ * $C0_J$ * $TEMP9_{1,1}$ + $80_J$ * $TEMP9_{2,1}$ + $C0_J$ * $C0_J$ * $TEMP9_{3,1}$ TEMP10 <sub>3,2</sub> = $-80_J$ * $C0_J$ * $TEMP9_{1,2}$ + $80_J$ * $TEMP9_{2,2}$ + $C0_J$ * $C0_J$ * $TEMP9_{3,2}$ TEMP10 <sub>3,3</sub> = $-80_J$ * $C0_J$ * $TEMP9_{1,3}$ + $80_J$ * $TEMP9_{2,3}$ + $C0_J$ * $C0_J$ * $TEMP9_{3,3}$ [TEMP11] = [TEMP7] + [TEMP10]  [EEJ] = [0,C_J] * [TEMP11] $ 0_J = 0_J + 0_J * \Delta x $ $ 0_J = 0_J + 0_J * \Delta x $ $ 0_J = 0_J + 0_J * \Delta x $ $ 0_J = 0_J + 0_J * \Delta x $ $ 0_J = 0_J + 0_J * \Delta x $ [EEE] = [EEK] + [EKJ]	,	TEMP10 = SØ, * SØ, * TEMP9, - + CØ, * TEMP9, - SØ, * CØ, * TEMP9, -
TEMP10 <sub>3,2</sub> = $- S\theta_J * C\theta_J * TEMP9_{1,2} + S\theta_J * TEMP9_{2,2} + C\theta_J * C\theta_J * TEMP9_{3,2}$ TEMP10 <sub>3,3</sub> = $- S\theta_J * C\theta_J * TEMP9_{1,3} + S\theta_J * TEMP9_{2,3} + C\theta_J * C\theta_J * TEMP9_{3,3}$ [TEMP11] = [TEMP1] + [TEMP10]  [EEJ] = $[0,C_J] * [TEMP11]$ $\theta_J = \theta_J + \theta_J * \Delta t$ $\theta_J = \theta + \theta_J * \Delta t$ $\theta_J = \theta + \theta_J * \Delta t$ $\theta_J = \theta + \theta_J * \Delta t$		TEMP10, = - S0, * CØ, * TEMP9, + + SØ, * TEMP9, + + CØ, * CO, * TEMP9, +
TEMP103,3 = $-80_J * CØ_J * TEMP9_{1,3} + SØ_J * TEMP9_{2,3} + CØ_J * CØ_J * TEMP9_{3,3}$ [TEMP11] = [TEMP10]  [EEJ] = $[0,C_J] * [TEMP11]$ $0_J = 0_J + 0_J * \Delta t$ $0_J = \emptyset + 0_J * \Delta t$ $0_J = \emptyset + 0_J * \Delta t$ $0_J = \emptyset + 0_J * \Delta t$		$\text{TEMP10}_{3.2} = -\text{SO}_{1} * \text{CO}_{1} * \text{TEMP9}_{1.2} + \text{SO}_{1} * \text{TEMP9}_{2.2} + \text{CO}_{1} * \text{CO}_{2} * \text{TEMP9}_{3.2}$
$\begin{bmatrix} \text{TEMP1}] &= \begin{bmatrix} \text{TEMP1} \end{bmatrix} &+ \begin{bmatrix} \text{TEMP10} \end{bmatrix} \\ & & & & & & & & & & & & & & & & & &$		TEMP10, 2 = - S0; * CØ; * TEMP9, 3 + SØ; * TEMP9, 3 + CØ; * CO; * TEMP9, 2
$\theta_{J} = \theta_{J} + \hat{\theta}_{J} * \Delta t$ $\theta_{J} = \theta + \hat{\theta}_{J} * \Delta t$ $EEE = EEE + FFJ$ $EEE = EEE + EEJ$		TEMP11] = TEMP7] + TEMP10]
	1	[mm] [o3o4] [vanex2]
		$\theta_{J} = \theta_{J} + \hat{\theta}_{J} * \Delta t$
[EEE] = [EEK] + [EKJ]		$g_{J} = g + g_{J} * \Delta t$
[EEE] = [EEK] + [EKJ]		
		65 ♥
		· FRF = FRF + FRJ
(GO TO 10) ^		. [ [ [ [ [ [ [ [ [ [ [ [ [ [ [ [ [ [ [
(GO TO 10) ^	•	
		(GO TO 10) ^ ◀
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ENTER  M1,1 = I_0,1,1 + I_1,1,1 + m_1 * doly * (R <sub>1</sub> yCo <sub>1</sub> - R <sub>1</sub> sO <sub>1</sub> ) + m <sub>1</sub> * + m <sub>2</sub> * (R <sub>2</sub> yCo <sub>1</sub> - R <sub>2</sub> sO <sub>1</sub> ) * (do <sub>1</sub> y + l <sub>2</sub> yCo <sub>1</sub> - l <sub>2</sub> sO <sub>1</sub> ) + m <sub>2</sub> * (R <sub>2</sub> ySo <sub>1</sub> + R <sub>2</sub> sO <sub>1</sub> ) * (do <sub>1</sub> z + l <sub>2</sub> ySo <sub>1</sub> + l <sub>2</sub> zO <sub>1</sub> ) + m <sub>3</sub> * (R <sub>3</sub> yOo <sub>1</sub> - R <sub>3</sub> sO <sub>1</sub> ) * (do <sub>1</sub> z + l <sub>2</sub> ySo <sub>1</sub> + l <sub>2</sub> zO <sub>1</sub> ) + m <sub>3</sub> * (R <sub>3</sub> yOo <sub>1</sub> - R <sub>3</sub> sO <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 3yOo <sub>1</sub> - d <sub>1</sub> 3zSo <sub>1</sub> + l + m <sub>3</sub> * (R <sub>3</sub> ySo <sub>1</sub> + R <sub>3</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 3ySo <sub>1</sub> + d <sub>1</sub> 3zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> yCo <sub>1</sub> - R <sub>4</sub> zSo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4yCo <sub>1</sub> - d <sub>1</sub> 4zSo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> + l + m <sub>4</sub> * (R <sub>4</sub> ySo <sub>1</sub> + R <sub>4</sub> zOo <sub>1</sub> ) * (do <sub>1</sub> z + d <sub>1</sub> 4ySo <sub>1</sub> + d <sub>1</sub> 4zCo <sub>1</sub> * (do <sub>1</sub> z + d <sub>1</sub> 4zCo <sub>1</sub>	dolm * dolm * doll * do	(R <sub>1y</sub> S0 <sub>1</sub> l <sub>3zS01</sub> l <sub>3zC01</sub> l <sub>4zS01</sub>	) )		
$\begin{array}{c} M_{1,1} = I_{0,1,1} + I_{1,1,1} + m_1 * d_{01y} * (R_{1y}C\theta_1 - R_{1z}S\theta_1) + m_1 * \\ + m_2 * (R_{2y}C\theta_1 - R_{2z}S\theta_1) * (d_{01y} + \ell_{2y}C\theta_1 - \ell_{2z}S\theta_1) \\ + m_2 * (R_{2y}S\theta_1 + R_{2z}C\theta_1) * (d_{01z} + \ell_{2y}S\theta_1 + \ell_{2z}C\theta_1) \\ + m_3 * (R_{3y}G\theta_1 - R_{3z}S\theta_1) * (d_{01y} + d_{13y}C\theta_1 - d_{13z}S\theta_1 + \ell_{2z}C\theta_1) \\ + m_3 * (R_{3y}S\theta_1 + R_{3z}C\theta_1) * (d_{01z} + d_{13y}S\theta_1 + d_{13z}C\theta_1 + \ell_{2z}C\theta_1) \\ + m_4 * (R_{4y}C\theta_1 - R_{4z}S\theta_1) * (d_{01y} + d_{14y}C\theta_1 - d_{14z}S\theta_1 + \ell_{2z}C\theta_1) \\ + m_4 * (R_{4y}S\theta_1 + R_{4z}C\theta_1) * (d_{01z} + d_{14y}S\theta_1 + d_{14z}C\theta_1 + \ell_{2z}C\theta_1) \\ \end{array}$	l <sub>3y</sub> co <sub>1</sub> - l <sub>3y</sub> so <sub>1</sub> + l <sub>4y</sub> co <sub>1</sub> - l <sub>4y</sub> so <sub>1</sub> +	l <sub>3z</sub> so <sub>1</sub> l <sub>3z</sub> co <sub>1</sub> l <sub>4z</sub> so <sub>1</sub>	) )	•	
$\begin{array}{c} M_{1,1} = I_{0,1,1} + I_{1,1,1} + m_1 * d_{01y} * (R_{1y}C\theta_1 - R_{1z}S\theta_1) + m_1 * \\ + m_2 * (R_{2y}C\theta_1 - R_{2z}S\theta_1) * (d_{01y} + \ell_{2y}C\theta_1 - \ell_{2z}S\theta_1) \\ + m_2 * (R_{2y}S\theta_1 + R_{2z}C\theta_1) * (d_{01z} + \ell_{2y}S\theta_1 + \ell_{2z}C\theta_1) \\ + m_3 * (R_{3y}G\theta_1 - R_{3z}S\theta_1) * (d_{01y} + d_{13y}C\theta_1 - d_{13z}S\theta_1 + \ell_{2z}C\theta_1) \\ + m_3 * (R_{3y}S\theta_1 + R_{3z}C\theta_1) * (d_{01z} + d_{13y}S\theta_1 + d_{13z}C\theta_1 + \ell_{2z}C\theta_1) \\ + m_4 * (R_{4y}C\theta_1 - R_{4z}S\theta_1) * (d_{01y} + d_{14y}C\theta_1 - d_{14z}S\theta_1 + \ell_{2z}C\theta_1) \\ + m_4 * (R_{4y}S\theta_1 + R_{4z}C\theta_1) * (d_{01z} + d_{14y}S\theta_1 + d_{14z}C\theta_1 + \ell_{2z}C\theta_1) \\ \end{array}$	l <sub>3y</sub> co <sub>1</sub> - l <sub>3y</sub> so <sub>1</sub> + l <sub>4y</sub> co <sub>1</sub> - l <sub>4y</sub> so <sub>1</sub> +	l <sub>3z</sub> so <sub>1</sub> l <sub>3z</sub> co <sub>1</sub> l <sub>4z</sub> so <sub>1</sub>	) )		
$\begin{array}{c} + \text{ m}_2 & \text{* } (\text{R}_{2y}\text{S}\theta_1 + \text{R}_{2z}\text{G}\theta_1) & \text{* } (\text{d}_{01z} + \text{l}_{2y}\text{S}\theta_1 + \text{l}_{2z}\text{G}\theta_1) \\ + \text{ m}_3 & \text{* } (\text{R}_{3y}\text{G}\theta_1 - \text{R}_{3z}\text{S}\theta_1) & \text{* } (\text{d}_{01y} + \text{d}_{13y}\text{G}\theta_1 - \text{d}_{13z}\text{S}\theta_1 + \text{l}_{2z}\text{G}\theta_1) \\ + \text{ m}_3 & \text{* } (\text{R}_{3y}\text{S}\theta_1 + \text{R}_{3z}\text{G}\theta_1) & \text{* } (\text{d}_{01z} + \text{d}_{13y}\text{S}\theta_1 + \text{d}_{13z}\text{G}\theta_1 + \text{l}_{1z}\text{G}\theta_1) \\ + \text{ m}_4 & \text{* } (\text{R}_{4y}\text{G}\theta_1 - \text{R}_{4z}\text{S}\theta_1) & \text{* } (\text{d}_{01y} + \text{d}_{14y}\text{G}\theta_1 - \text{d}_{14z}\text{S}\theta_1 + \text{l}_{1z}\text{G}\theta_1) \\ + \text{ m}_4 & \text{* } (\text{R}_{4y}\text{S}\theta_1 + \text{R}_{4z}\text{G}\theta_1) & \text{* } (\text{d}_{01z} + \text{d}_{14y}\text{S}\theta_1 + \text{d}_{14z}\text{G}\theta_1 + \text{l}_{1z}\text{G}\theta_1) \\ \end{array}$	l <sub>3y</sub> co <sub>1</sub> - l <sub>3y</sub> so <sub>1</sub> + l <sub>4y</sub> co <sub>1</sub> - l <sub>4y</sub> so <sub>1</sub> +	l <sub>3z</sub> so <sub>1</sub> l <sub>3z</sub> co <sub>1</sub> l <sub>4z</sub> so <sub>1</sub>	) )		
$\begin{array}{c} + \text{ m}_2 & \text{* } (\text{R}_2 \text{y}^{\text{S}} \text{9}_1 + \text{R}_2 \text{g}^{\text{C}} \text{9}_1) & \text{* } (\text{d}_{01} \text{g} + \text{l}_2 \text{y}^{\text{S}} \text{9}_1 + \text{l}_{2z} \text{c}^{\text{G}}_1) \\ + \text{ m}_3 & \text{* } (\text{R}_3 \text{y}^{\text{G}} \text{9}_1 - \text{R}_3 \text{g}^{\text{S}} \text{9}_1) & \text{* } (\text{d}_{01} \text{y} + \text{d}_{13} \text{y}^{\text{G}} \text{9}_1 - \text{d}_{13} \text{g}^{\text{S}} \text{9}_1 + \text{l}_{13} \text{g}^{\text{G}} \text{9}_1 \\ + \text{ m}_3 & \text{* } (\text{R}_3 \text{y}^{\text{S}} \text{9}_1 + \text{R}_3 \text{g}^{\text{C}} \text{9}_1) & \text{* } (\text{d}_{01} \text{g} + \text{d}_{13} \text{y}^{\text{S}} \text{9}_1 + \text{d}_{13} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{13} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{13} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 \\ + \text{ m}_4 & \text{* } (\text{R}_4 \text{y}^{\text{C}} \text{9}_1 - \text{R}_4 \text{g}^{\text{C}} \text{9}_1) & \text{* } (\text{d}_{01} \text{g} + \text{d}_{14} \text{y}^{\text{C}} \text{9}_1 - \text{d}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 \\ + \text{ m}_4 & \text{* } (\text{R}_4 \text{y}^{\text{S}} \text{9}_1 + \text{R}_4 \text{g}^{\text{C}} \text{9}_1) & \text{* } (\text{d}_{01} \text{g} + \text{d}_{14} \text{y}^{\text{S}} \text{9}_1 + \text{d}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 \\ + \text{m}_4 & \text{* } (\text{R}_4 \text{y}^{\text{S}} \text{9}_1 + \text{R}_4 \text{g}^{\text{C}} \text{9}_1) & \text{* } (\text{d}_{01} \text{g} + \text{d}_{14} \text{y}^{\text{S}} \text{9}_1 + \text{d}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 \\ + \text{m}_4 & \text{* } (\text{R}_4 \text{y}^{\text{S}} \text{9}_1 + \text{R}_4 \text{g}^{\text{C}} \text{9}_1) & \text{* } (\text{d}_{01} \text{g} + \text{d}_{14} \text{g}^{\text{S}} \text{9}_1 + \text{d}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 \\ + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 \\ + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 + \text{l}_{14} \text{g}^{\text{C}} \text{9}_1 \\ + \text{l}_{14} \text{g}$	l <sub>3y</sub> co <sub>1</sub> - l <sub>3y</sub> so <sub>1</sub> + l <sub>4y</sub> co <sub>1</sub> - l <sub>4y</sub> so <sub>1</sub> +	l <sub>3z</sub> so <sub>1</sub> l <sub>3z</sub> co <sub>1</sub> l <sub>4z</sub> so <sub>1</sub>	) )		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	<sup>2</sup> 4y <sup>CO</sup> 1 - <sup>2</sup> 4y <sup>SO</sup> 1 +	23± 01 L42 501	)		
$\begin{array}{c} + m_4 * (R_{4y}S\theta_1 - R_{4z}S\theta_1) * (d_{01y} + d_{14y}S\theta_1 - d_{14z}S\theta_1 + \mathcal{L} \\ + m_4 * (R_{4y}S\theta_1 + R_{4z}G\theta_1) * (d_{01z} + d_{14y}S\theta_1 + d_{14z}G\theta_1 + \mathcal{L} \end{array}$	4y <sup>00</sup> 1 +	~4e <sup>50</sup> 1			
M <sub>1,2</sub> = I <sub>0,1,2</sub> + I <sub>1,1,2</sub> * G <sub>0</sub> - I <sub>1,1,3</sub> * S <sub>0</sub> - m <sub>1</sub> * R <sub>1x</sub> * d <sub>0</sub> ly					
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	°1'				
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	θ <sub>1</sub> ) θ <sub>1</sub> )				
$ \begin{array}{l} \mathbf{M_{1,4}} = \mathbf{I_{1,1,1}} - \mathbf{m_{1}} * \mathbf{d_{01z}} * ((\mathbf{m_{0}/m}) * \mathbf{d_{01z}} - \mathbf{R_{1y}S\theta_{1}} - \mathbf{R_{1z}C\theta_{1}}) \\ + \mathbf{m_{1}} * \mathbf{d_{01y}} * (\mathbf{R_{1y}C\theta_{1}} - \mathbf{R_{1z}S\theta_{1}} - (\mathbf{m_{0}/m}) * \mathbf{d_{01y}}) \\ - \mathbf{m_{2}} * (\mathbf{d_{01z}} + \mathbf{\ell_{2y}S\theta_{1}} + \mathbf{\ell_{2z}C\theta_{1}}) * ((\mathbf{m_{0}/m}) * \mathbf{d_{01z}} - \mathbf{R_{2y}S\theta_{1}} - (\mathbf{m_{0}/m}) * \mathbf{d_{01z}} - \mathbf{R_{2y}S\theta_{1}}) \\ + \mathbf{m_{2}} * (\mathbf{d_{01y}} + \mathbf{\ell_{2y}C\theta_{1}} - \mathbf{\ell_{2z}S\theta_{1}}) * (\mathbf{R_{2y}C\theta_{1}} - \mathbf{R_{2z}S\theta_{1}} - (\mathbf{m_{0}/m}) * \mathbf{d_{01z}} - \mathbf{R_{2y}S\theta_{1}} - (\mathbf{m_{0}/m}) * \mathbf{d_{01z}} \\ - \mathbf{m_{3}} * (\mathbf{d_{01z}} + (\mathbf{d_{13y}} + \mathbf{\ell_{3y})S\theta_{1}} + (\mathbf{d_{13z}} + \mathbf{\ell_{3z}}) * S\theta_{1}) * \\ + \mathbf{m_{3}} * (\mathbf{d_{01y}} + (\mathbf{d_{13y}} + \mathbf{\ell_{3y})C\theta_{1}} - (\mathbf{d_{13z}} + \mathbf{\ell_{3z}}) * S\theta_{1}) * \\ - \mathbf{m_{4}} * (\mathbf{d_{01z}} + (\mathbf{d_{14y}} + \mathbf{\ell_{4y})S\theta_{1}} + (\mathbf{d_{14z}} + \mathbf{\ell_{4z}}) * S\theta_{1}) * \\ + \mathbf{m_{4}} * (\mathbf{d_{01y}} + (\mathbf{d_{14y}} + \mathbf{\ell_{4y})C\theta_{1}} - (\mathbf{d_{14z}} + \mathbf{\ell_{4z}}) * S\theta_{1}) * \\ \end{array} $	Se <sub>1</sub> - R <sub>2</sub> ; m <sub>c</sub> /m) * ( ((m <sub>c</sub> /m) (R <sub>3y</sub> Ce <sub>1</sub> ; ((m <sub>c</sub> /m)	<sup>d</sup> 01y) * <sup>d</sup> 01z ~ - R <sub>3z</sub> S9 * <sup>d</sup> 01=	1 R <sub>4.</sub> 50	~ R <sub>A_</sub> CO <sub>1</sub> )	
$\begin{array}{c} M_{1,5} = -m_3 * R_{3x} * (S_{3x} * l_{3x} - S_{3x} * l_{3x}) \\ +m_3 * R_{3y} * (-S_{3y} * l_{3x} + S_{3x} * l_{3y}) \end{array}$					
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	y <sup>C9</sup> 1 - R	1 <sub>2</sub> 50 <sub>1</sub> )			
•				. ,.,	
CONTINUE TO THE NEXT PA	AGE			· :	!
	* ,	•	· · · · · · · · · · · · · · · · · · ·		

Application	SUBROUTINE EMCALC CONTINUED	Drawn By GARY JOHNSON	of _
	CONTINUED FROM	THE PREVIOUS PAGE	
+ + + + +	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ce_1$ ) $ce_2 ce_1$ ) * $(d_{01x} + \ell_{2y} se_1 + \ell_{2z} ce_1)$ $ce_{13z} ce_1 + \ell_{3y} se_1 + \ell_{3z} ce_1)$ $ce_{14z} ce_1 + \ell_{4y} se_1 + \ell_{4z} ce_1)$	
M <sub>2,4</sub> =	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$d_{13x}c\theta_1 + \mathcal{L}_{3y}s\theta_1 + \mathcal{L}_{3x}c\theta_1)$ $d_{14x}c\theta_1 + \mathcal{L}_{4y}s\theta_1 + \mathcal{L}_{4x}c\theta_1)$ $d_{15y}c\theta_1$ $d_{15y}c\theta_1 + d_{15y}c\theta_1$ $d_{15y}c\theta_1 + d_{15y}c\theta_1$	
M <sub>2,5</sub> =	$\begin{array}{l} \text{m}_{4} * (d_{01x} + d_{14x} + \ell_{4x}) * (R_{4y}^{2}G_{1} - R_{4x}^{2}S_{1}) \\ \text{m}_{3} * R_{3x} * (-S_{3x} * \ell_{3y} + S_{3y} * \ell_{3x}) \\ \text{m}_{3} * R_{3x} * (-S_{3y} * \ell_{3x} + S_{3x} * \ell_{3y})) * C_{1} \\ \text{m}_{3} * R_{3x} * (-S_{3y} * \ell_{3y} + S_{3y} * \ell_{3y}) \\ \text{m}_{3} * R_{3x} * (S_{3x} * \ell_{3y} + S_{3y} * \ell_{3y})) * S_{1} \\ \text{m}_{3} * R_{3x} * (S_{3x} * \ell_{3x} - S_{3x} * \ell_{3y})) * S_{1} \\ \end{array}$	• • •	
- 1	$(m_4 * R_{4x} * (- S_{4x} * l_{4y} + S_{4y} * l_{4x})$ $n_4 * R_{4x} * (- S_{4y} * l_{4x} + S_{4x} * l_{4y})) * C$ $(- m_4 * R_{4y} * (- S_{4x} * l_{4y} + S_{4y} * l_{4z})$ $n_4 * R_{4x} * (S_{4z} * l_{4x} - S_{4x} * l_{4z})) * SO_1$	9 <sub>1</sub>	,
- 1	$^{1}_{0,3,1} + ^{1}_{1,2,1} * ^{8}_{01} + ^{1}_{1,3,1} * ^{8}_{01} - ^{m}_{1} * ^{8}_{1} * ^{4}_{01x} + ^{4}_{2x}) * (^{8}_{2y} ^{8}_{01} + ^{8}_{2z} ^{2}_{01}) * (^{8}_{3y} ^{8}_{01} + ^{8}_{3z} ^{2}_{01} + ^{8}_{3z} ^{2}_{01} * ^{4}_{01x} + ^{4}_{13x} + ^{4}_{4x}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{3z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{3z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{4y} ^{8}_{01} + ^{8}_{4z} ^{2}_{01} + ^{8}_{4z} ^{2}_{01}) * (^{8}_{$	, ,	
- 1	$^{1}_{0,3,2} + ^{1}_{1,2,2} \times ^{2}_{01} \times ^{8}_{01} - ^{1}_{1,2,3} \times ^{8}_{01}^{2}$ $^{1}_{1} \times ^{4}_{01y} \times ^{2}_{1} \times ^{8}_{1} + ^{2}_{1x} \times ^{6}_{1})$ $^{1}_{2} \times ^{2}_{1} \times ^{8}_{1} + ^{2}_{2x} \times ^{6}_{1} \times ^{4}_{01y} + ^{4}_{13y} \times ^{6}_{1} - ^{4}_{13y} \times ^{6}_{1} + ^{4}_{13y} \times ^{6}_{1} + ^{4}_{14y} \times ^{6}_{1$	$\ell_{2\mathbf{z}}^{\mathbf{s}\mathbf{e}_{1}}$ ) $i_{13\mathbf{z}}^{\mathbf{s}\mathbf{e}_{1}} + \ell_{3\mathbf{v}}^{\mathbf{c}\mathbf{e}_{1}} - \ell_{3\mathbf{z}}^{\mathbf{s}\mathbf{e}_{1}}$	

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M_{3,3} = I_{0,3,3} + I_{1,2,2} * S\theta_1^2 + I_{1,2,3} * C\theta_1 * S\theta_1 + I_{1,3,2} + I_{1,3,3} * C\theta_1^2
             + m_3 * R_{3x} * (d_{01x} + d_{13x} + \tilde{L}_{3x})
             \begin{array}{l} + \; \text{m}_{3} \; * \; (\text{R}_{3y}\text{C}\theta_{1} \; - \; \text{R}_{3z}\text{S}\theta_{1}) \; * \; (\text{d}_{01y} \; + \; \text{d}_{13y}\text{C}\theta_{1} \; - \; \text{d}_{13z}\text{S}\theta_{1} \; + \; \ell_{3y}\text{C}\theta_{1} \; - \; \ell_{3z}\text{S}\theta_{1}) \\ + \; \text{m}_{4} \; * \; \text{R}_{4x} \; * \; (\text{d}_{01x} \; + \; \text{d}_{14x} \; + \; \ell_{4x}) \end{array}
              + m_4 * (R_{4y}^{C\theta_1} - R_{4z}^{C\theta_1}) * (d_{01y} + d_{14y}^{C\theta_1} - d_{14z}^{C\theta_1} + \ell_{4y}^{C\theta_1} - \ell_{4z}^{C\theta_1})
 M_{3,4} = I_{1,1,2} * S\theta_1 + I_{1,1,3} * C\theta_1
             + m_1 * d_{01x} * ((m_0/m) * d_{01z} - R_{1y}S\theta_1 - R_{1z}C\theta_1)
             + m_2 * (d_{01x} + \ell_{2x}) * ((m_0/m) * d_{01z} - R_{2y}S\theta_1 - R_{2z}C\theta_1)
              \begin{array}{l} {\rm M_{3,5} = (m_{3} * R_{3z} * (-S_{3z} * l_{3y} + S_{3y} * l_{3z})} \\ {\rm - m_{3} * R_{3x} * (-S_{3y} * l_{3x} + S_{3x} * l_{3y}) * S\theta_{1}} \\ {\rm + (-m_{3} * R_{3y} * (-S_{3z} * l_{3y} + S_{3y} * l_{3z})} \\ {\rm + m_{3} * R_{3x} * (S_{3z} * l_{3x} - S_{3x} * l_{3z})) * C\theta_{1}} \end{array} 
\begin{array}{l} {\rm M_{3,6}} = ({\rm m_4 * R_{4z} * (- S_{4z} * l_{4y} + S_{4y} * l_{4z})} \\ - {\rm m_4 * R_{4z} * (- S_{4y} * l_{4z} + S_{4z} * l_{4y}) * S\theta_{1}} \\ + ({\rm -m_4 * R_{4y} * (- S_{4z} * l_{4y} + S_{4y} * l_{4z})} \\ + {\rm m_4 * R_{4z} * (S_{4z} * l_{4z} - S_{4z} * l_{4z})} \end{array}
 DEFINE SOME REOCCURRING TERMS
SR_3 = m_3 * (d_{13y} + l_{3y})

SR_4 = m_3 * (d_{13z} + l_{3z})
SR_5 = m_4 * (d_{14y} + l_{4y})
                                                                                                                                                                                                                                    ا شير:
SR_6 = m_4 * (d_{14z} + \ell_{4z})
SR_1 = I_{1,1,2} - m_2 * \ell_{2y} * R_{2x} - SR_3 * R_{3x} - SR_5 * R_{4x}

SR_2 = I_{1,1,3} - m_2 * \ell_{2z} * R_{2x} - SR_4 * R_{3x} - SR_6 * R_{4x}
M_{4,1} = I_{1,1,1} + m_2 * (\ell_{2z} * R_{2z} + \ell_{2y} * R_{2y}) + SR_4 * R_{3z} + SR_3 * R_{3y} + SR_6 * R_{4z} + SR_5 * R_{4y}
M_{4,2} = SR_1 * C9_1 - SR_2 * S9_1
M_{4,3} = SR_1 * S\theta_1 + SR_2 * C\theta_1
REDEFINE SR AND SR 2
 \begin{array}{l} {\rm SR}_1 \; = \; ({\rm m_o/m}) \; \div \; ({\rm d_{01y}} \; \div \; {\rm C\theta_1} \; + \; {\rm d_{01z}} \; \div \; {\rm S\theta_1}) \\ {\rm SR}_2 \; = \; ({\rm m_o/m}) \; \div \; (- \; {\rm d_{01y}} \; \div \; {\rm S\theta_1} \; + \; {\rm d_{01z}} \; \div \; {\rm C\theta_1}) \\ \end{array}
```

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Application SUBROUTINE EMCALG CONTINUED	DateOCTOBER-1970 Page of4
Procedure	Drawn By GARY JOHNSON

#### CONTINUED FROM THE PREVIOUS PAGE

$$\begin{bmatrix} M_{4,4} = I_{1,1,1} + m_2 \times (L_{2x} \times (R_{2x} - SR_2) + L_{2y} \times (R_{2y} - SR_1)) \\ + SR_4 \times (R_{3x} - SR_2) + SR_3 \times (R_{3y} - SR_1) + SR_6 \times (R_{3x} - SR_2) + SR_3 \times (R_{3y} - SR_1) \\ + SR_4 \times (R_{3x} - SR_2) + L_{3x} + (R_{3y} - SR_1) \times L_{3y} \times S_{3x} \\ - (R_{3y} - SR_1) \times L_{3x} + S_{3y} - (R_{3x} - SR_2) \times L_{3x} \times S_{3x} \\ \end{bmatrix}$$

$$\begin{bmatrix} M_{4,5} = m_3 \times (((R_{3x} - SR_2) \times L_{3x} + (R_{3y} - SR_1) \times L_{3y} \times S_{3x} \\ - (R_{4y} - SR_1) \times L_{4x} \times S_{4y} - (R_{4x} - SR_2) \times L_{3x} \times S_{3x} \\ \end{bmatrix}$$

$$\begin{bmatrix} M_{5,1} = -m_2 \times ((R_{3x} \times R_{3x} + L_{3x} \times R_{3y}) \times (00_1 + L_{3x} \times R_{3y}) \times S_{4x} \\ - (R_{4y} - SR_1) \times L_{4x} \times S_{4y} - (R_{4x} - SR_2) \times L_{4x} \times S_{4x} \\ \end{bmatrix}$$

$$\begin{bmatrix} M_{5,1} = -m_3 \times (((L_{3x} \times R_{3x} + L_{3x} \times R_{3y}) \times S_{01} + L_{3x} \times R_{3y} \times S_{01}) \times S_{3y} \\ + (-L_{3y} \times R_{3x} + L_{3x} \times R_{3y}) \times S_{01} + L_{3x} \times R_{3y} \times S_{01} \times S_{3y} \\ + (-L_{3y} \times R_{3x} + L_{3x} \times R_{3y}) \times S_{01} + L_{3x} \times R_{3y} \times S_{01} \times S_{3y} \\ + (-L_{3y} \times R_{3x} + L_{3x} \times R_{3y}) \times S_{01} + L_{3x} \times R_{3y} \times S_{01} \times S_{3y} \\ \end{bmatrix}$$

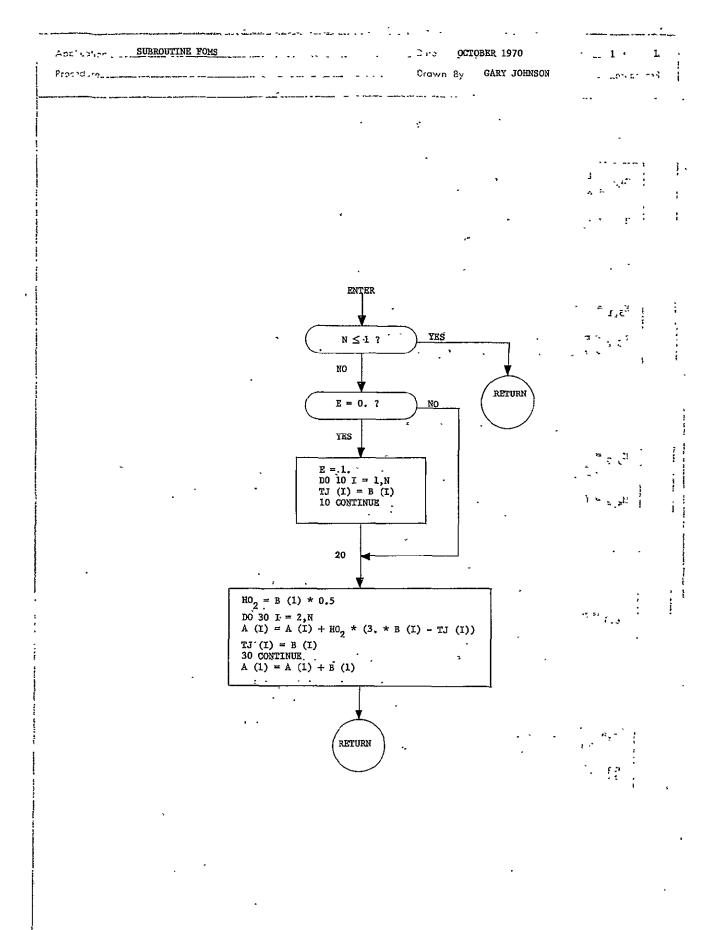
$$\begin{bmatrix} M_{5,1} = m_3 \times (((L_{3x} \times R_{3x} + L_{3x} \times R_{3y}) \times S_{01} + L_{3x} \times R_{3y} \times S_{01}) \times S_{3y} \\ + (-L_{3y} \times R_{3x} + S_{3x} + L_{3x} \times R_{3y}) \times S_{3y} + (-R_{3x} \times R_{3y} \times S_{01}) \times S_{3x} \\ \end{bmatrix}$$

$$\begin{bmatrix} M_{5,3} = m_3 \times (((-R_{3y} \times R_{3x} + L_{3x} \times R_{3y}) \times S_{3y} + (-R_{3x} \times R_{3y} \times S_{3y}) \times S_{3y} \\ + (-L_{3y} \times R_{3x} + S_{3y} \times S_{3y} + (-R_{3y} \times R_{3y} + L_{3x} \times R_{3y}) \times S_{3x} \\ \end{bmatrix}$$

$$\begin{bmatrix} M_{5,4} = m_3 \times L_{3x} \times ((-R_{3y} \times R_{3x} + L_{3x} \times R_{3y}) \times S_{3y} + (-R_{3x} \times R_{3y} \times S_{3y}) \times S_{3y} \\ + (-L_{3y} \times R_{3x} + L_{3x} \times R_{3y} \times S_{3y} + (-R_{3x} \times R_{3y}) \times S_{3y} \\ + (-(L_{3y} \times R_{3y} + R_{3y} \times R_{3y} + R_{3y} \times R_{3y}) \times S_{3y} + (-R_{3y} \times R_{3y}) \times S_{3y} \\ \end{bmatrix}$$

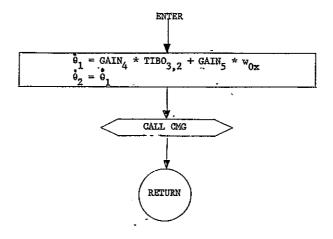
$$\begin{bmatrix} M_{5,6} = m_3 \times ((-R_{3y} \times R_{3y} + R_{3y} + R_{3y} \times R_{3y}) \times S_{3y} + (-R_{3y} \times R_{3y}) \times S_{3y} \\ + (-(L_{3y} \times R_{3y} + R_{3y} + R_{3y} \times R_{3y}) \times S_{3y} + (-R_{3y} \times R_{3y}) \times S_{3y} \\ \end{bmatrix}$$

$$\begin{bmatrix} M_{5,1} = m_3 \times ((-R_{3y} + R_{3y} + R_{3y} + R_{3y} \times R_{3y} \times R_{3y}) \times S_{3y} \times S_$$

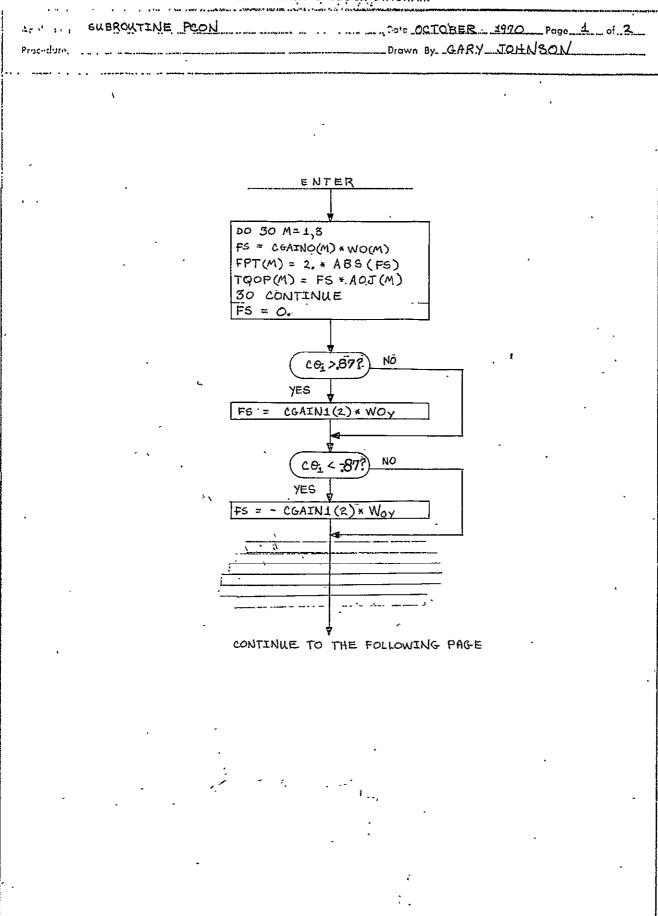


FLOW CHART & BLOCK DIAGRAM Date 0000BER 1970 TUSSE Page 1 of 1 SUBROUTINE GGRAD Application \_\_\_\_\_ Procedure\_\_ Drawn By ... GARY JOHNSON ... ENTER  $= - S9_0 * TIBO_{1,1} + C9_0 * TIBO_{2,1}$  $= - S9_0 * TIBO_{1,2} + C9_0 * TIBO_{2,2}$ DB<sub>y</sub>  $= - S\theta_0 * TIBO_{1,3} + C\theta_0 * TIBO_{2,3}$  $\frac{\text{REMP}}{F_{01}} = \frac{DB_{x}}{DB_{x}} * \frac{R_{ox}}{R_{ox}} + \frac{DB_{y}}{DB_{y}} * \frac{R_{oy}}{R_{oy}} + \frac{DB_{z}}{DB_{z}} * \frac{R_{oz}}{R_{o}}$ =  $I_{0,1,1} * DB_{x} + I_{0,1,2} * DB_{y} + I_{0,1,3} * DB_{z}$ =  $I_{0,2,1} * DB_{x} + I_{0,2,2} * DB_{y} + I_{0,2,3} * DB_{z}$ =  $I_{0,3,1} * DB_{x} + I_{0,3,2} * DB_{y} + I_{0,3,3} * DB_{z}$  $TQ_{OGz} = 3. * C_1 * (DB_x * A_y - DB_y * A_x)$  $DB_{x} = -S\theta_{0} * TIBO_{1,1} + C\theta_{0} * TIBO_{2,1}$  $= c9_1 * (- s9_0 * TIBO_{1,2} + c9_0 * TIBO_{2,2})$  $+ S\theta_{1} * (- S\theta_{0} * TIBO_{1,3} + C\theta_{0} * TIBO_{2,3})$  $= - s\theta_1 * (- s\theta_0 * TIEO_{1,2} + c\theta_0 * TIEO_{2,2})$  $+ ce_1 * (- se_0 * TIBO_{1,3} + ce_0 * TIBO_{2,3})$  $REMP = DB_{x} * R_{1x} + DB_{y} * R_{1y} + DB_{z} * R_{1z}$  $= C_1 * m_1 * (3. * REMP * DE - R_1)$ = I<sub>1,1,1</sub> \* DB<sub>x</sub> + I<sub>1,1,2</sub> \* DB<sub>y</sub> + I<sub>1,1,3</sub> \* DB<sub>z</sub>  $= I_{1,2,1} * DB_{x} + I_{1,2,2} * DB_{y} + I_{1,2,3} * DB_{z}$ =  $I_{1,3,1} * DB_{x} + I_{1,3,2} * DB_{y} + I_{1,3,3} * DB_{z}$  $TQ_{1Gx} = 3. * C_1 * (DB_y * A_z - DB_z * A_y)$  $TQ_{1Gy} = 3. * C_1 * (DB_x * A_x - DB_x * A_z)$  $TQ_{1C} = 3. * C, * (DB_ * A_ - DB_ * A_ )$ RETURN

GARY JOHNSON



	Application.	SUBROUTINE MULT	DateOGTOBER_1970Page1of1
	Procedure		Drawn_ByGARY_JOHNSON
			•
			·
			ENTER
		<u> </u>	
			$C_x = A_{1,1} * B_x + A_{1,2} * B_y + A_{1,3} * B_z$
		l	$C_y = A_{2,1} * B_x + A_{2,2} * B_y + A_{2,3} * B_z$
			$C_z = A_{3,1} * B_x + A_{3,2} * B_y + A_{3,3} * B_z$ $F_{-} = D_{-} * E_{-} * D_{-} * D_{-} * E_{-} * D_{-} * D_{-} * E_{-} * D_{-} $
			E 3,1
		ļ	F <sub>1,3</sub> = D <sub>1,1</sub> * E <sub>1,3</sub> + D <sub>1,2</sub> * E <sub>2,3</sub> + D <sub>1,3</sub> * E <sub>3,3</sub>
			$F_{2,1} = D_{2,1} * F_{1,1} + D_{2,2} * F_{2,1} + D_{2,3} * F_{3,1}$
			$F_{2,2} = D_{2,1} * E_{1,2} + D_{2,2} * E_{2,2} + D_{2,3} * E_{3,2}$
			<sup>1</sup> 2,3 <sup>2</sup> 2,1 <sup>2</sup> 1,3 <sup>2</sup> 2,2 <sup>2</sup> 2,3 <sup>1</sup> 2,3 <sup>2</sup> 3,3
			"3,1 "3,1 "1,1 "3,2 "2,1 "3,3 "3,1 F = D <sub>2</sub> , * E <sub>1</sub> , + D <sub>2</sub> , * E <sub>2</sub> , + D <sub>3</sub> , * E <sub>4</sub> , + D <sub>4</sub> , * E <sub>5</sub> , + D <sub>5</sub> , * E <sub>7</sub> , + D <sub>7</sub> <sub>7</sub> ,
			$F_{33} = D_{31} + E_{13} + D_{32} + E_{23} + D_{33} + E_{33}$
		<del>- 11</del>	
			<u>,                                     </u>
			RETURN
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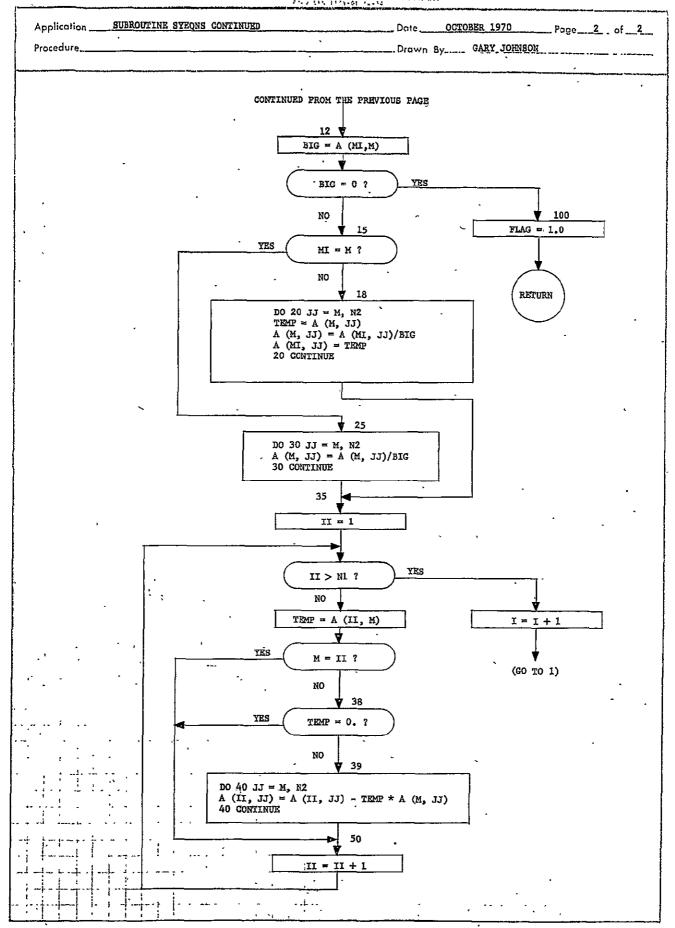
	Date_ <u>OCTOBER 1970</u> Page 2of 2 Drawn ByGARY_JOHNSON
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S9. >.872	, No
YES YES	
F5 = CGAIN1 (2) * W	PE
se <sub>1</sub> < -87/2	NO
YES	
FS = - CGAIN1 (2) *	Woz
FPT(4) = 2. * ABS(FS	5)
TQ + P(2) = FS * A + J + A + J + A + A + A + A + A + A +	-5P)
TQ1P(1) = FS * A1J	(4)
(RETURN)	
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Application \_\_\_\_SUBROTTINE RECALC OCTOBER 1970 Page I of 1 Drawn By GARY JOHNSON Procedure\_\_ ENTER CALL SCALC  $\begin{array}{l} L_2 = d_{12} + s * s_2 \\ l_{3x} = l_3 * s_3 \\ l_{3y} = -l_3 * c_3 * s_3 \\ l_{3z} = l_3 * c_3 * s_{3y} \\ l_{4x} = l_4 * s_4 \\ l_{4y} = -l_4 * c_4 * s_4 \\ l_{4z} = l_4 * c_4 * s_{4y} \\ R_{1x} = (m_0/m) * d_{01x} - (m_2/m) * l_{2x} \\ - (m_3/m) * (d_{12x} + l_{3x}) \\ - (m_1/m) * (d_{12x} + l_{12x}) \end{array}$  $\begin{array}{l} - (m_3/m) \cdot * (d_{13x} + \mathcal{L}_{3x}) \\ - (m_4/m) \cdot * (d_{14x} + \mathcal{L}_{4x}) \\ R_{1y} &= (m_0/m) \cdot * (d_{01y} \cdot c\theta_1 + d_{01z} \cdot s\theta_1) \\ - (m_2/m) \cdot * \mathcal{L}_{2y} \\ - (m_3/m) \cdot * (d_{13y} + \mathcal{L}_{3y}) \\ - (m_4/m) \cdot * (d_{14y} + \mathcal{L}_{4y}) \\ R_{1z} &= (m_0/m) \cdot (-d_{01y} \cdot s\theta_1 + d_{01z} \cdot c\theta_1) \\ - (m_1/m) \cdot * \mathcal{L}_{3y} &= (m_0/m) \cdot (-d_{01y} \cdot s\theta_1 + d_{01z} \cdot c\theta_1) \\ \end{array}$  $\overline{R}_2 = \overline{R}_1 + \overline{\ell}_2$  $\vec{R}_3 = \vec{R}_1 + \frac{\vec{d}_{13}}{\vec{d}_{13}} + \vec{\ell}_{3}$ RETURN

Application SUBROUTINE SCALC Procedure	
ENTER	•
s = 0.	
RETURN	
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J	SUBROUTINE SPEALE		OCTOBER 1970 Page 1 of 1  By GARY JOHNSON	
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		ENTER  S = 0.	 	
		RETURN		
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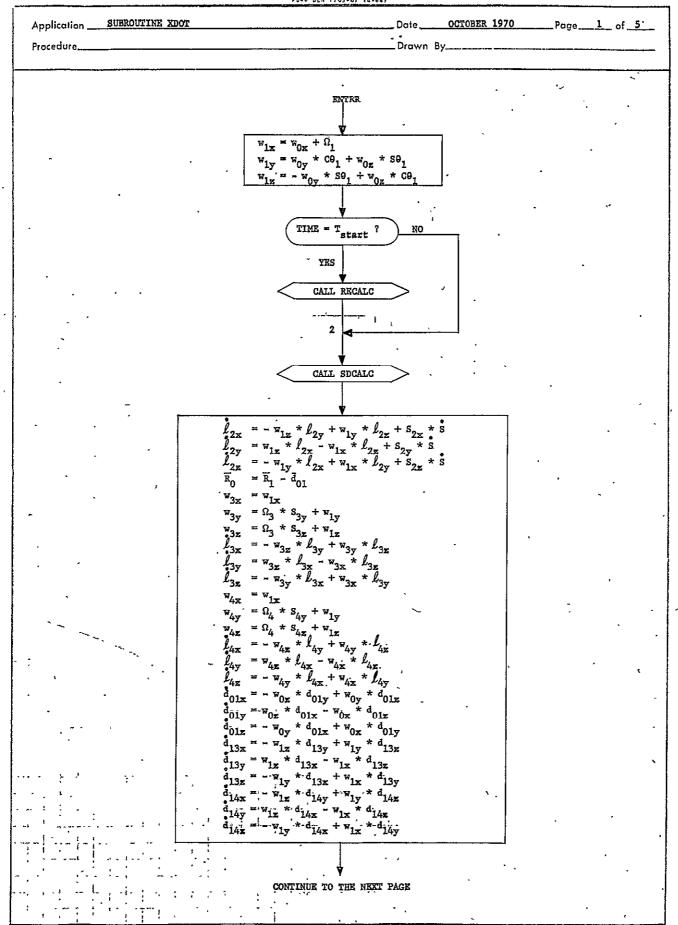
Application SUBROUTINE SYEONS		DateOCTOBER 1970	age1of2_
Procedure		Drawn ByGARY JOHNSON	·
			<del></del>
SUBROUTINE SYEQNS (A, N, NR,	NC, FLAG)		
	enter		
	<u> </u>	<del></del>	
	DIMENSION A (NR,	NC)	
	N1 = N		
	N2 = N1 + 1 NO = N1 - 1		
	FLAG = 0.		
	I = 1 \		
	<u> </u>	1	
	1	_	\
	( I > N1 ?	YES	
	110	70	
	NO		
	M = I	( RETURN )	
	MI = M ·		
	MI = N1 ?	YES	
	NO		
	<b>¥</b> 2 II = M		
•			
-	II > NO ?	YES	,
	- NO		
,	▼		•
	[   A (MI, M)   ≥   A (II + I	, M) ? YES	•
	NO		
	5 🔻		
	MI = II + 1		
* *	10		
•			
1	II = II + 1		
	,	· · · · · · · · · · · · · · · · · · ·	•
		<u> </u>	
	12 🔻	· · · · · · · · · · · · · · · · · · ·	• • • • • • • • • • • • • • • • • • • •
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Application	SUBROUTINE TORKO1		Date 00	TOBER 1970	_Page	1	of1_	_
Procedure			•	GARY JOHNSON				_
	•							
		enter						
		<u> </u>	МО	-				
		TIME = TSTART ?		7				
		YES						
	F-	<u> </u>	<del></del>					
		$X_C = -GAIN_2 * \Omega$ AFOUR (2) = $X_C$						
	<u> </u>	- AFOOK (2) - K <sub>C</sub>						
		10		- <del></del>				
	_	ATIONE (I) - BY						
		AFOUR (1) = TIME BFOUR (1) = $\Delta t$ $\dot{x}_{G}$ = $GAIN_{3}$ * ( $\Omega_{1}$						
		$x_{C} = GAIN_{3} * (\Omega_{1} - G)$ BFOUR (2) = $\dot{x}_{C}$	· SP)					
•		117012 (2) = 1 <sub>G</sub>			,			
- •		CALL FOMS						
		GALLII FORES			•			
	777 PPMF A n. AA	X = AFOUR (2)	) TA					
KTANANA A VY	* ***	Tmotor = GAIN <sub>2</sub> * C Tfrict = GAIN <sub>1</sub> * S	1 °C IN (Ω,)				•	
	,	Trict = GAIN1 * S  T0-1 = Tmotor +	Triet	,				
			,					
	1	,						_
			1 * rm = 1		•			
		RETURN	-					<b></b> .
	— , , , , , , , , , , , , , , , , , , ,		-	* * * *		•	-	
	·	<del>-</del>					· · · · · ·	
- F   K		<del>                                    </del>	<u> </u>	<u> </u>	• •		·~~~~	24
<del>                                      </del>	<del></del>		<del> </del>			<b>.</b>		
<del></del>		<del>                                     </del>		<del></del>	-	-	ļ	
	1 - ,~						†	<u></u>
				<del>_</del>	<u> </u>			+
<del>                                     </del>		·	- + + - + - + - + - +	++++-	╁╁╅		1-	<u>.</u>
<del></del>	<del>                                     </del>	-	;	++++	<del>   </del>	_	+-+	<del>-</del>
	<del>17                                      </del>				<u> </u>			Т_

Application SUBROUTINE TORKL3	Date OCTOBER 1970 Page 1 of 1
Procedure	Drawn By GARY JOHNSON
*	· · · · · · · · · · · · · · · · · · ·
SUBROUTINE TORKI3 (T13, CP1, CP2, THETA3, OMEGA3)	
. ` .	
T <sub>1-3</sub> = - CF <sub>1</sub> * Ω <sub>3</sub> - CP	2 * <sup>6</sup> 3
RETURN	
	,
•	

Application <u>SUBROUTINE TORK14</u> Procedure	_ Date _ Drawn		OBER 1970 GARY_JOHNSON	_ Page1_	
SUBROUTINE TORK14 (T14, CP1, CP2, THETA4, OMEGA4)	M-21				
•					
ENTER $T_{1\longrightarrow 4} = - CP_{1} * \Omega_{4} - CP_{2} *$	(0 <sub>4</sub> -	<del>π</del> )	T		
RETURN	-		_1	·	
L.				-	,
· · · · · · · · · · · · · · · · · · ·					
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Application_	SUBROUTINE XDOT CONTINUED	DateOCTOBER 1970
Procedure		Drawn By GARY JOHNSON
	CONTINUED	FROM THE PREVIOUS PAGE
	\$ - (- (-) + 3	
	"lx "("o("") " "01x - (m <sub>3</sub> /m) * (d <sub>1</sub>	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
	$\dot{R}_{1y} = (m_0/m) * (\dot{d}_{01y})$ $= (m_1/m) * (\dot{d}_{01y})$	* $^{\circ}$
	R <sub>1z</sub> = (m <sub>0</sub> /m) * (= d <sub>0</sub>	3y - ~3y - ~4y - ~4y - 1y * \$01 + d01x * \$01 - (m2/m) * \$\begin{array}{c} 2z \end{array}
	- (m <sub>3</sub> /m) * (d <sub>1</sub>	$3z + \ell_{3z}$ - $(m_4/m) * (d_{14z} + \ell_{4z})$
	$\ddot{R}_2 = \dot{R}_1 + \dot{L}_2$	
	$\dot{\bar{R}}_3 = \dot{\bar{R}}_1 + \dot{\bar{d}}_{13} + \dot{\bar{L}}_3$	
-	$\frac{\bullet}{R}_4 = \frac{\bullet}{R}_1 + \frac{\bullet}{d}_{14} + \frac{\bullet}{L}_4$	
•		
i 		CALL MULT (I.E. $\overline{H}_0 = [I_0] * \overline{w}_0$ )
		<u> </u>
ix	. <	CALL MULT (I.E. $\overline{H}_1 = [I_1] * \overline{w}_1$ )
- - 24-		<u> </u>
	h' <sub>3x</sub> = m <sub>3</sub> * (. h' <sub>3y</sub> = m <sub>3</sub> * (.	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
	h'3z = m3 * (-	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
		$\begin{array}{cccccccccccccccccccccccccccccccccccc$
	h <sub>4z</sub> = m <sub>4</sub> * (-	- l <sub>4y</sub> * R <sub>4x</sub> + l <sub>4x</sub> * R <sub>4y</sub> )
	iy iy :	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
	- m <sub>3</sub> * (·	- d <sub>13x</sub> + R <sub>3x</sub> + d <sub>13x</sub> + R <sub>3x</sub> )
	h <sub>1z</sub> = h <sub>1z</sub> + 1	14z 4z 14z 14z 14z 14z 13z 14z 14z 14z 14z 14z 14z 14z 14z 14z 14
		7
	~ m <sub>4</sub> * (c	$\begin{array}{cccccccccccccccccccccccccccccccccccc$
		<b>↓</b>
	CONTIN	IUE TO THE NEXT PAGE
		•

Application \_\_\_\_SUBROUTINE XDOT CONTINUED OCTOBER 1970 Page 3 of 5 Procedure. Drawn By GARY JOHNSON CONTINUED FROM THE PREVIOUS PAGE TIME = T ? YES + h<sub>4x</sub> DO 4 I = 1, 3H<sub>CMGI</sub> = FFF<sub>I</sub> DO 4 J = 1, 3 H<sub>CMGI</sub> = EEEE I,J \* W<sub>OJ</sub> + H<sub>CMGI</sub> 4 CONTINUE TINUE  $= H_{0x} + h'_{1x} + (-d_{01x} * C\theta_1 + d_{01y} * S\theta_1) * SUM_2$   $+ (d_{01z} * S\theta_1 + d_{01y} * C\theta_1) * SUM_3 + H_{CMGX}$   $= H_{0y} + C\theta_1 * h'_{1y} - S\theta_1 * h'_{1z} + d_{01x} * SUM_1$   $- d_{01x} * S\theta_1 * SUM_2 - d_{01x} * C\theta_1 * SUM_3 + H_{CMGY}$   $= H_{0z} + S\theta_1 * h'_{1y} + C\theta_1 * h'_{1z} - d_{01y} * SUM_1$   $+ d_{01x} * C\theta_1 * SUM_2 - d_{01x} * S\theta_1 * SUM_3 + H_{CMGZ}$  $\begin{array}{l} {\rm AJ_{1x} = m_2 * \ell_{2x} + m_3 * d_{13x} + m_3 * \ell_{3x} + m_4 * d_{14x} + m_4 * \ell_{4x}} \\ {\rm AJ_{1y} = m_2 * \ell_{2y} + m_3 * d_{13y} + m_3 * \ell_{3y} + m_4 * d_{14y} + m_4 * \ell_{4y}} \\ {\rm AJ_{1z} = m_2 * \ell_{2z} + m_3 * d_{13z} + m_3 * \ell_{3z} + m_4 * d_{14z} + m_4 * \ell_{4z}} \end{array}$ - TIME \* W IGRAVF = 0 ? МО CALL GGRAD 10 CONTINUE TO THE FOLLOWING PAGE

Application	SUBROUTINE XDOT CONTINUED	Date OCTOBER 1970	Pagr 4, ~ ~ !
Procedure		Drawn ByGARY JOHNSÓN	
		name and a second se	THE THE PERSON AND VALUE AND ADDRESS AND A
	CONTINUED FROM	THE PREVIOUS PAGE	
		, <b>*</b>	
	$\overline{F}_0 = \overline{F}_{01}$	•	
	$\overline{F}_{1} = \overline{F}_{1\underline{1}}$ $\overline{T}_{0EF} = \overline{TQ}_{0G} + \overline{TQ}_{0P}$		;
•	$\overline{T}_{1EF} = \overline{TQ}_{1G} + \overline{TQ}_{1P}$		
	TERM1(1) = $(m_0 - m) * d_{01x} - AJ_{1x}$ TERM1(2) = $(m_0 - m) * d_{01y} - C\theta_1$	* AJ,_ + S9, * AJ,_	
	TERM1 (3) = $(m_0 - m) * d_{01z} - S\theta_1$	* AJ <sub>1y</sub> - C9 <sub>1</sub> * AJ <sub>1z</sub>	
	TERM2 (1) = $m_0 * d_{01x} - AJ_{1x}$ TERM2 (2) = $m_0 * (C\theta_1 * d_{01y} + S\theta_1)$	* d <sub>o.</sub> ) = AJ.	
	$TERM2(3) = m_0 * (-S\theta_1 * d_{01y} + CC$	01 * q <sup>01z</sup> ) - ylz	
	$ATCPT2_{1,1} = 0.$ $ATCPT2_{1,2} = - TERM2(3)$		
	$ATGPT2_{1,3} = TERM2(2)$		
	$ATCPT2_{2,1} = C9_1 * TERM2(3) + S9_1$	* TERM2(2)	
	$ATCPT2_{2,2} = -s0_1 * TERM2(1)$ $ATCPT2_{2,3} = -c0_1 * TERM2(1)$		
-	$ATCPT2_{3,1} = S0_1 * TERM2(3) - C0_1$	* TERM2(2)	
	ATCPT2 <sub>3,2</sub> = $G_{1}$ * TERM2(1) ATCPT2 <sub>3,3</sub> = $-S_{1}$ * TERM2(1)	-	
	H = Woz * H - Woy * H + (- TER		
	+ (ATCPT2 <sub>1,1</sub> * F <sub>1x</sub> + ATCPT2 <sub>1,2</sub> + T <sub>OKFX</sub> + T <sub>1KFX</sub>	* F <sub>1y</sub> + ATCPT2 <sub>1,3</sub> * F <sub>1z</sub> )/m	
	$\dot{H}_{v} = - w_{0z} * H_{x} + w_{0x} * H_{z} + (TER)$	M1(3) * F <sub>0x</sub> - TERM1(1) * F <sub>0x</sub> )/m	
	+ (ATCPT22,1 * Flx + ATCPT22,2	* F <sub>1y</sub> + ATCPT2 <sub>2,3</sub> * F <sub>1z</sub> )/m	
	$+ T_{OEFY} + C\theta_1 * T_{1EFY} - S\theta_1 * T_{EFY}$ $H_z = W_{Oy} * H_x - W_{Ox} * H_y + (- TER)$	M1(2) * F <sub>0+</sub> + TERM1(1) * F <sub>0+</sub> )/m	
	+ (ATCPT2 <sub>3,1</sub> * F <sub>1x</sub> + ATCPT2 <sub>3,2</sub> + T <sub>OEFZ</sub> + SO <sub>1</sub> * T <sub>LEFY</sub> + CO <sub>1</sub> * T	* F <sub>1y</sub> + ATCPT2 <sub>3,3</sub> * F <sub>1z</sub> )/m	
	+ TOERZ + SU1 * 11EFY + CU1 *	11EFZ	
٠	CALL	TORKO1	
	$h_{1x} = -w_{1y} * h_{1z} + w_{1z} * h_{1y}$		
	+ R <sub>1y</sub> * (- m <sub>2</sub> * $\hat{l}_{,2z}$ - m <sub>3</sub> * (d	${}_{13x} + \hat{\ell}_{3x}) - {}_{4} * (\hat{d}_{14x} + \hat{\ell}_{4x}))$ ${}_{13y} + \hat{\ell}_{3y}) - {}_{4} * (\hat{d}_{14y} + \hat{\ell}_{4y}))$	
	$\begin{array}{c} -R_{1x} * (-m_2 * l_{2y} - m_3 * (d \\ -AJ_{1y} * (-F_{0y} * S9_1/m + F_{0z}) \end{array}$	$\frac{13y + L_{3y}}{13y} - m_4 * (d_{14y} + L_{4y})$ * $c_{9y}/m$	
	+ Al <sub>1z</sub> * (F <sub>Ov</sub> * C9 <sub>1</sub> /m + F <sub>Oz</sub> *	Se <sub>1</sub> /m)	-
	+ AJ <sub>1z</sub> * F <sub>1y</sub> /m - AJ <sub>1y</sub> * F <sub>1z</sub> /m	+ T <sub>1KFX</sub> + T <sub>0</sub> 1	

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Application	SUBROUTINE XDOT CONTINUED	Date OCTOBER 1970 Page 5 of 5
Procedure		Drawn By GARY JOHNSON
·····		
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		•
	CONTINUED FROM THE	PREVIOUS PAGE
	. ]	
	CALL TORK	13
	2. 1	
	G <sub>3</sub> = - S <sub>3y</sub> * (W <sub>1z</sub> * h <sub>3z</sub> - W <sub>1x</sub> * h <sub>3z</sub> )	
	$-S_{3x} * (w_{1x} * h_{3y} - w_{1y} * h_{3x})$	
·	+ m <sub>3</sub> * S <sub>3y</sub> * ( $l_{3x}$ * R <sub>3x</sub> - $l_{3x}$ *	R <sub>3z</sub> )
	- (m-/m) * 8 * (l <sub>1</sub> * (F <sub>1</sub> + F	"3x" - ) = k * (= F. * S9. + F. * C9. + F. ))
	$- l_{3y} * (F_{0x} + F_{1x})) + T_{1 \rightarrow 3}$	
•		
-	CALL TOR	<u>R14</u>
• • •	·	
· - :	c - c + (- + t - + t )	
	$G_{4} = -S_{4y} * (w_{1x} * h_{4x} - w_{1x} * h_{4z})$ $-S_{4x} * (w_{1x} * h_{4y} - w_{1y} * h_{4x})$	•
	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	· R,_)
	+ m <sub>4</sub> * S <sub>4x</sub> * ( $l_{4x}$ * R <sub>4y</sub> - $l_{4y}$ * )	R <sub>4</sub> *)
	$- (m_{\underline{A}}/m) * S_{\underline{A}\underline{y}} * (\ell_{\underline{A}\underline{z}} * (F_{\underline{O}\underline{x}} + F$	$R_{4x}$ ) $1x$ ) - $\ell_{4x}$ * (- $F_{0y}$ * $S\theta_1$ + $F_{0z}$ * $C\theta_1$ + $\ell_{1z}$ )) $\theta_1$ + $F_{0z}$ * $S\theta_1$ + $F_{1y}$ )
	- (m <sub>4</sub> /m) * S <sub>4x</sub> * (L <sub>4x</sub> * (F <sub>0y</sub> * C(	91 + F <sub>0z</sub> * S9 <sub>1</sub> + F <sub>1y</sub> )
and a second	$-\ell_{4y} * (F_{0x} + F_{1x})) + T_{1 \rightarrow 4}$	·
		•
		` .
·	RETUR	и) ,
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## APPENDIX E, SUBROUTINE DESCRIPTIONS

## Subroutine: CMG

Purpose: This subroutine computes the angular momenta produced by the CMGs located on body 0. Either 2 degree of freedom, 1 degree of freedom or reaction wheels can be accommodated.

## Input/output:

I/O	Fortran Name	Math Symbol	Definition
I	NUMCMG	N CMG	The number of CMGs located on body 0
I	IDOF(K)	IDOF	The number of degrees of freedom for the kth CMG
I	HW (K)	Ħ	The momentum of the kth wheel
I	AII(J,K,M)	I <sub>I</sub>	The inertia matrix of the inner gimbal including wheel. The subscript J refers to the CMG being referenced, K, and M are dimensioned 3 and accommodate the inertia matrix
· I	Alo(J,K,M)	Î <sub>o</sub>	The inertia matrix of the outer gimbal. The meaning of the subscripts are the same as AII(J,K,M)
I	THATA(J)	θj	The inner gimbal angle
I	FEE(J)	øj	The outer gimbal angle
I	(L)AȚAHT	ė,	The time-derivative of 0
I	FEED(J)	ø <sub>j</sub>	The time derivative of $\emptyset$
0	fff(M)	f	The total angular momentum of the CMGs which is not a function of the angular rates
0	EEE(M,N)	E	The total angular momentum of the CMGs which is a function of the angular rates. For further discussion see the Appendix

Subroutines required: None

Discussion: None

#### Subroutine ATT

Purpose: This routine simulates the action of an attitude control system using reaction jets.

## Input/output:

I/O	Fortran Name	Math Symbol	Definition
I	wo (3)	<i>ѿ</i> 0	Angular rates of Body O (stator)
I	TIBO (3,3)	[I,B] <sub>0</sub>	Transformation from Body 0 to inertial frame
r	CA(3)	CA	Direction cosines of reference direction
ı	TIME	t	Time
r	BODY1I(1,	1) I <sub>lei</sub> _	Moment of inertia around spin axis of rotor
I	OMEGA1	$\Omega_{\!_1}$	Gimbal rate of rotor
I	DELTAT	Δt	Time increment per step
0	TQOP (3)		Control torques
0	FAT (8)		Control forces
I	AOJ(3)	,	Reaction jet lever arms

Subroutines required: none

Equations programmed: 
$$\Delta K = \Omega_1 L_{ii} \sin \beta/2/(5.5 + \Delta t)$$
 coordinate transformations

Discussion: A complete description of this routine is given in the final report.

In order to activate the attitude control function it is necessary to set both IPROPF and IATTIF in the input data.

The attitude section also requires designation of the three direction cosines (CA(1), CA(2), CA(3)) of the direction in

inertial space at which control is desired. For a reorientation maneuver the initial orientation of the spin axis is inertial space read in (TIBOI(1,1), TIBOI(2,1), TIBOI(2,3) are the initial direction cosines of the spin axis in inertial space) can be specified different from GA. It is necessary, however, to ensure that the angle between the initial direction of the spin axis and the direction to which it is commanded to be redirected be not greater than  $60^{\circ}$  for the attitude control routine employed in this program.

The propulsion control section must be supplied with appropriate jet couple lengths and control gains for removal of transverse angular rates (see discussion on PCON subroutine). The control can be on either Body 0 or Body 1 or on both.

Subroutine: EMCALC

Purpose: Subroutine EMCALC assembles the M matrix used in the calculations from which the angular velocities are computed.

# Input/output:

	1		
1/0	Fortran Name	Math Symbol	Definition
I	THETA1	91	Angular displacement between bodies 0 and 1
I	R1(3)	ř <sub>1</sub>	Vector distance from system c.m. to the c.m. of body 1
I	R2(3)	<b>F</b> 2	Vector distance from system c.m. to the c.m. of body 2
I	R3(3)	₹3	Vector distance from system c.m. to the c.m. of body 3
Ī	R4(3)	<b>F</b> <sub>4</sub>	Vector distance from system c.m. to the c.m. of body 4
I	EL2(3)	$ar{l}_2$	Vector position of the movable mass
I	EL3(3)	$ar{l}_3$	Vector position of body 3 from hinge line s3
I	EL4(3)	$ar{l}_4$	Vector position of body 4 from hinge line s
I	D01(3)	₫ <sub>01</sub>	Vector distance from the c.m. of body 0 to the hinge line of body 1
I	D13(3)	₫ <sub>13</sub>	Vector distance from the c.m. of body 1 to the hinge 1 ne of body 3
I. I	D14(3)	₫ <sub>14</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 4
I	BOMASS	<sup>m</sup> o	Mass of body 0

A			
I	32MASS	<sup>m</sup> 2	Mase of body 2
r	B3MASS	m <sub>3</sub>	Mass of body 3
I	B4MASS	m <sub>4</sub>	Mass of body 4
I	TOTMAS	<sup>m</sup> 3	Mass of composite body
I	•	A <sub>1</sub>	Coordinate transformat on from body 0 to body 1
I	R1(3)	Ŧ <sub>1</sub>	Vector distance from system c.m. to the c.m. of body 1
I	R2(3)	ī <sub>2</sub>	Vector distance from the system c.m. to the c.m. of body 2
ľ	R3(3)	₹ <sub>3</sub>	Vector distance from the system c.m. to the c.m. of body 3
I	BODY01(3,3)	I <sub>O</sub>	The inertia matrix of body 0
I	BODY11(3,3)	I <sub>1</sub>	The inertia matrix of body 1
I	S3(3)	- s₃	The hinge line of body 3
I	<sup>:</sup> <b>s</b> 4(3)	' <u>-</u> 84	The hinge line of body 4
ø	EM(6,6)	m 1j	The M matrix

Subroutines required: None

Equations programmed: The M matrix is related to the angular momenta and the angular velocities by the equation shown below:

#### Subroutine FOMS

Purpose: This integration routine calculates values of a set of variables at time  $t_{n+1}$  from their values at  $t_n$  and their derivatives at times  $t_n$  and  $t_{n-1}$ .

Calling Sequence: FOMS (A, B, N, E, TJ)

#### Input/output:

1/0	Fortran Name	Math Symbol	Definition
I	A(I)	×i,n	ith variable at time t; i = 1, 2; I = i + 1
0	A(I)	× i,n+l	i <u>th</u> variable at time t <sub>n+1</sub>
I	B(I)	. *i,n	ith derivative at time t
I	И	m	Number of variables to be inte- grated; m = N-1
1,0	E		Flag to use current derivatives for past derivatives on first integration
I	TJ(I)	*i,n-1	ith derivative at time t
0	TJ(I)	*i,n	i <u>th</u> derivative at time t <sub>n</sub> )storage for next step

Subroutines required: none

Equations programmed: 
$$x_{n+1} = x_n + 1/2 \Delta t (3x_n - x_{n-1})$$

Discussion: The variables and derivatives are indexed over values of I from 2 to N. B(1) is used to bring in  $\Delta t$ . A(1) is set up to be used for time but is not used in this program. On the first integration the current derivatives are also used as past derivatives since no past derivatives are available.

## Subroutine GGRAD

Purpose: This subroutine calculates the forces and torques due to gravity gradient on Body 0 and Body 1.

Inj it/output:

I/O	Fortran Name	Math Symbol	Definition
I	THETO	θ <sub>0</sub>	True anomaly
I	тіво (3,3)	[1,B] <sub>0</sub>	Transformation from Body 0 to inertial frame
Į	BODYOI (3,3)	[1 <sub>0</sub> ]	Moment of inertia matrix of Body 0
I	BODY11(3,3)	[1 <sub>1</sub> ]	Moment of inertia matrix of Body 1
. 0	F01(3)	F <sub>01</sub>	Force on Body O due to gravity gradient
0	F11 (3)	F <sub>11</sub>	Force on Body 1 due to gravity gradient
0	TQ0G(3)		Torque on Body O due to gravity gradient
o	TQ1G (3)		Torque on Body l due to gravity gradient
I	C1		Gravitation constant and earth radius factor
I	BOMASS	m <sub>o</sub>	Mass of Body 0
r	B1MASS ·	<sup>m</sup> 1	Mass of Body 1
I	THETA1	θ <sub>1</sub>	Gimbal angle of Body l
I	RO (3)	ro	Distance between centers of mass of Body 0 and system
I	RI (3)	'n	Distance between centers of mass of Body 1 and system

Equations programmed:

Torque: 
$$T_G = -\frac{3\mu}{R_0^5} \overline{R}_0 \times [\overline{1} \cdot \overline{R}_0]$$

Force: 
$$F_G = \frac{\mu m}{R_0^3} (\bar{r} - \frac{3\bar{R}_0 \cdot \bar{r}}{R_0^2} \bar{R}_0)$$

where  $R_0 = distance$  to center of earth

r = distance between center of mass of body and center of mass of system

Discussion: The translational motion is limited to circular orbits in the X-Y inertial plane in order to simplify transformations and relationships in this subroutine. Gravity gradient effects on Body 2, Body 3 and Body 4 are neglected.

Subroutine: HCON

Purpose: The subroutine contains the control laws in terms of gimbal angle rates for the CMGs. In most cases the user must furnish his own control law.

## Input /output:

I/O	Fortran Name	Math Symbol	Definition
I			Any program variables to be used in the control law
0	FEED(J)	ø <sub>J</sub>	Outer gimbal rate of the Jth CMG
·0	THATAD(J)	e <sub>J</sub>	Inner gimbal rate of the Jth CMG

Subroutines required: CMG

Discussion: None

#### Subroutine MULT

Purpose: Subroutine MULT multiplies either and 3  $\times$  3 matrix by a 3  $\times$  1 matrix or a 3  $\times$  3 matrix by a 3  $\times$  3 matrix.

Calling sequence: CALL MUTL (C, A, B, F, D, E, MTYPE)

## Input/output:

1/0	Fortran Name	Math Symbol	Definition
1/0	Mame	Symbol	JELANILLION .
I.	A		A 3 x 3 matrix used in the matrix multiplication C = A x B
I	В		A 3 x 1 matrix used in the matrix multiplication C = A x B
<b>ø</b>	C		A 3 $\times$ 1 matrix which is the result of A $\times$ B
ľ	, Ď		A 3 x 3 matrix used in the matrix multiplication F = D x E
I	E		A 3 x 3 matrix used in the matrix multiplication F = D x E
Ø	·F		A 3 $\times$ 3 matrix which is the result of D $\times$ E
I	MTYPE		A flag which determines the type of matrix multiplication being performed. If MTYPE = 1 then C = A x B is performed, if MTYPE # 1 then D = E x F is performed.

Discussion: When subroutine MULT is used to multiply a 3  $\times$  3 matrix by a 3  $\times$  1 matrix variables F, D, E are dummies, when used to multiply two 3  $\times$  3 matrices then variables C, A, B are dummies.

#### Subroutine PCON

Purpose: To simulate a reaction jet control system for removing transverse components of angular velocity, maintaining the spin rate of the rotor and removing spin axis angular rates of the stator.

#### Input/output:

I/o	Fortran Name	Math Symbol	Definition
I	WO	$\bar{\omega}_0$	Angular rates of Body 0
I	THETA1	θ <sub>1</sub>	Angle of Body 1 with respect to Body 0
I	OMEGA1	$\Omega_{1}$	Angular velocity of Body 1 with respect to Body 0
I.	CGAINO(3)		Control gains of stator jets
I.	AOJ (3)	-	Stator jet couple arm length
I ,	CGAIN1(2)		Control gains of rotor jets
I.	A Alj(2)	,	Rotor jet couple arm length
.0	TQOP (3)		Control torques on stator
0.	TQ1P(3)		Control torques on rotor
0	FPT (5)		Control forces

Subroutines required: none

Equations programmed: none

Discussion: Certain restrictions on the configuration of the reaction jets have been assumed.

Associated with the torque around an axis there are four jets. One pair is in a pure couple to produce torque in one direction. The other pair, identical in location and strength, is oppositely directed. No torque is produced around axes other than the one designated.

In setting up input data for the reaction jet controls, the

control gain of the jets of the couple and the distance between the two jets forming the couple must be specified. Since the couples are similar for the two directions, this data is read only once for each axis.

The firing of jets on Body 1 (rotor) must be timed according to alignment with stator axes. Gimbal angle sensing is used in this routine to provide this ciming.

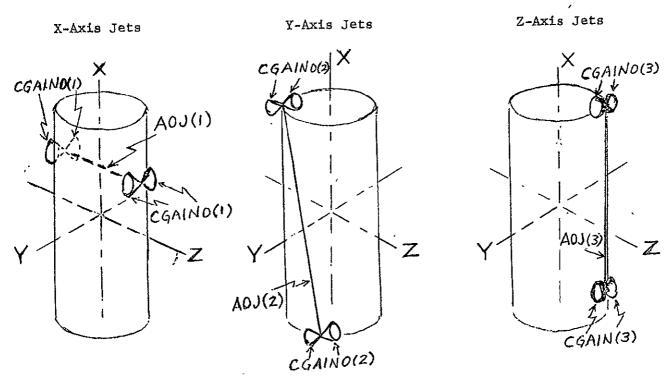
The PCON subroutine :imulates a reaction jet control on angular rates. Transvers: control torques are made proportional and opposite to transvers: velocities. Such a control is similar in effect to an external frictional force acting against transverse motion. For a transverse torque  $T_T$  related to the magnitude of transverse rate  $\omega_T$  by  $T_T = -K$   $\omega_T$  some estimate of the decrease in magnitude of transverse rate over a time interval t is given by  $\omega_T \approx \omega_{To}$  e-  $K/I_T$  t where  $\omega_{To}$  is the initial transverse angular rate and  $I_T = \sqrt{(I_0 + I_1)}$  ( $I_0 + I_1$ ). This estimate will be

good for jets on Body 0 where both transverse axes are controlled. For the single axis jets on the rotor the control will be much slower due to the time that the rotor spends in unfavorable positions.

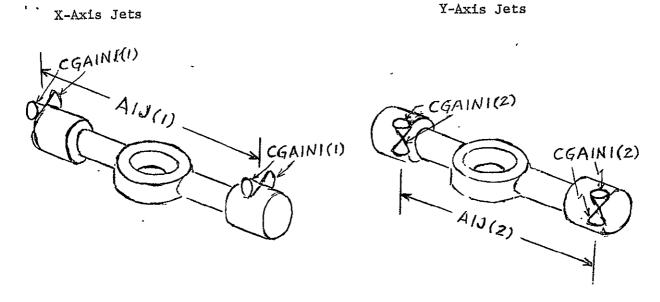
In Figure jet configurations are illustrated. Note that it is not necessary for jets to be symmetrically located with respect to any coordinate axes or planes. It is necessary, however, that the X-jet couple arm be parallel to the Y-Z plane, the Y-jet couple arm be parallel to the X-Z plane, etc. The data deck is simplified by requiring only magnitudes of jet couple arms without regard for actual directions or components.

The reaction jets are activated by setting IPROPF = 1 and supplying control gain and couple arm length data. If it is desired to leave a certain axis uncontrolled, the corresponding control gain is set to zero, but the couple arm length should be given some non-zero value in order to prevent division by zero in calculation of impulse contributions.

Body 0



Body 1



Subroutine: RECALC

Purpose: The purpose of this subroutine is to compute the distance from combined system center of mass to the center of mass of the various bodies.

## Input/output:

1/0	Fortran Name	Math Symbol	<b>Definition</b>		
I	BOMASS	<sup>m</sup> o	Mass of body 0		
I	B2MASS	<sup>m</sup> 2	Mass of body 2		
I	B3MASS	<sup>m</sup> 3	Mass of body 3		
I.	B4MASS	<sup>m</sup> 4	Mass of body 4		
ı	TOTMASS	m	Mass of composite body		
I	D01(3)	₫ <sub>01</sub>	Vector distance from the c.m. of body 0 to the hinge line of body 1		
ı	EL2(3)	$\overline{l}_2$	Vector position of the movable mass		
I	D13(3)	₫ <sub>13</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 3		
I	D14(3)	₫ <sub>14</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 4		
I	EL3(3)	$\ell_3$	Vector position of body 3 from the hinge line s <sub>3</sub>		
I	EL4(3)	· <u>Ĩ</u>	Vector position of body 4 from the hinge line s4		
o	R1(3)	ř <sub>1</sub>	Vector distance from system c.m. to the c.m. of body 1		
0	R2(3)	ř <sub>2</sub>	Vector distance from the system c.m. to the c.m. of body 2		

0	R3(3)	- r <sub>3</sub>	Vector distance from the system c.m. to the c.m. of body 3
0	R4(4)	r <sub>4</sub>	Vector distance from the system c.m. to the c.m. of body 4

Subroutines required: None

#### Equations programmed:

$$r_{1} = \frac{m_{0}}{m} \vec{d}_{01} - \frac{m_{2}}{m} \vec{l}_{2} - \frac{m_{3}}{m} (\vec{d}_{13} + \vec{l}_{3}) - \frac{m_{4}}{m} (\vec{d}_{14} + \ell_{4})$$

$$r_{2} = \frac{m_{0}}{m} d_{01} + (1 - \frac{m_{2}}{m}) \ell_{2} - \frac{m_{3}}{m} (d_{13} + \ell_{3}) - \frac{m_{4}}{m} (d_{14} + \ell_{4})$$

$$r_{3} = \frac{m_{0}}{m} d_{10} - \frac{m_{2}}{m} \ell_{2} + (1 - \frac{m_{3}}{m}) (d_{13} + \ell_{3}) - \frac{m_{4}}{m} (d_{14} + \ell_{4})$$

$$r_{4} = \frac{m_{0}}{m} d_{01} - \frac{m_{2}}{m} \ell_{2} - \frac{m_{3}}{m} (d_{13} + \ell_{3}) + (1 - \frac{m_{4}}{m}) (d_{14} + \ell_{4})$$

r<sub>1</sub>, r<sub>2</sub>, r<sub>3</sub>, r<sub>4</sub>

#### Subroutine SCALC

Purpose: This routine supplies the position of the movable mass, Body 2.

## Input/output:

1/0	Fortran Name	Math Symbol	Definition
0	S	S	Distance of Body 2 from D12 along direction S2

Note: Other I/O variables may be employed depending on the formulation of the subroutine.

Subroutines required: Not specified

Equations programmed: Not specified

Discussion: This subroutine will be constructed to suit the needs of the user. Any variables appearing in the common region can be employed as input/output variables.

#### Subroutine SDCALC

Purpose: This routine supplies the speed of the movable mass, Body 2.

#### Input/output:

I/O	Fortran Name	Math Symbol	Definition
0	SDOT	ŝ	Magnitude of velocity of Body 2 along direction S2.

Note: Other I/O variables may be employed depending on the formulation of the subroutine.

Subroutines required: Not specified

Equations programmed: Not specified

Discussion: This subroutine will be constructed to suit the needs of the user. Any variables appearing in the common region can be employed as input/output variables. Subroutine: SYEQNS(A,N,NR,NC,FLAG)

Purpose: Subroutine SYEQNS solves a set of linear simultaneous equations Ax = c to determine the column vector x.

## Input/output:

	· ·		
I/O	Fortran Name	Math Symbol	Defin <b>itio</b> n
1/0	A	A	A is the system matrix as depicted above. Also the answer x will appear as the N+1 at column of matrix A
I	N	N	N is the number of linear equations to be solved
I	NR	NR	NR is the number of rows in A
I	NC	NC	NC is the number of columns in A
0	FLAG	FLAG	If FLAG = 0 as solution exists if FLAG = 1 no solution exists
			_

Subroutines required: None

Discussion: None

Subroutine: TORK01

Purpose: The purpose of this subroutine is to compute the torque acting between bodies 0 and 1. The present version of TORKO1 contains a frictional torque as well as torque motor with appropriate control law.

## Input/output:

1/0	Fortran Name	Math Symbol	Definition
I			Any of the variables carried through common
0	T01	<sup>T</sup> 01	The torque acting between body 0 and body 1

Discussion: None ,

Subroutine: TORK13

Purpose: This subroutine computes the torque between body 1 and body 3.

## Input/output:

1/0	Fortran Name	Math Symbol	Definition.
l l	THETA3	θ <sub>3</sub>	Angular displacement of body 3 about the hinge line s <sub>3</sub>
; I	OMEGA3	3	Angular velocity of body 3 about the hinge line s
I	CP1	CP1	Gain for $\omega_3$
ı	CP2	CP2	Gain for $\theta_3$
0	T13	T <sub>13</sub>	The torque acting between bodies 1 and 3

Subroutines required: None

Equations programmed:

$$T_1 \longrightarrow 3 = - CP1 \times \omega_3 - CP2 \times \theta_3$$

Subroutine: TORK14

Purpose: This subroutine computes the torque acting between body 1 and body 4.

## Input/output:

1/0	Fortran Name	Math Symbol	Definition
I	THETA4	94	Angular displacement of body 4 about the hinge line $s_{4}^{}$
I	ØMEGA4	4	Angular velocity of body 4 about the hinge line s4
I	CP1 .	CP <sub>1</sub>	Gain for $\omega_4$
İ	CP2	CP <sub>2</sub>	Gain for $\theta_3$
0	T14	<sup>T</sup> 14	The torque acting between bodies 1 and 4

Subroutines required: None

Equation programmed:

$$T_{1 \longrightarrow 4} = - CP1 \times \omega_4 - CP2 \times (\theta_4 - \pi)$$

## Subroutine XDOT

Purpose: To compute the derivative of the unconstrained components of angular momenta as well as the variable required for these calculations.

Segment 1

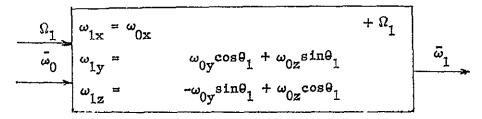
Purpose: To compute the angular velocity of body 1.

## Input/output:

1/0	Fortran Name	Math Symbol	Definition
I	OMEGA1	$\Omega_1$	Angular velocity between bodies 1 and 0
I	WO(3)	$\bar{\omega}_0$	Angular velocity of body 0
ø	W1(3)	$\bar{\omega}_1$	Angular velocity of body 1
I	THETA1	. 01	Angular displacement between bodies 1 and 0

Subroutines required: None

## Equations Programmed:



Discussion: The angular velocity of body 0  $(\bar{\omega}_0)$  is transformed to the body 1 coordinate system and is added to the primary gimbal rate to obtain the angular velocity of body 1  $(\bar{\omega}_1)$ .

## Segnant 2.

Purpose: To compute the vector position of the movable mass from the center-of-mass (c.m.) of body 1.

# Input/output:

I/O	Fortran Name	Math Symbol	Definition
I	S	s	Movable mass travel, a speci- fied scalar function of time
I	D12(3)	₫ <sub>12</sub>	Fixed vector (in body 1 coordinates) locating the path of movable mass from c.m. of body 1
I	§2 (3)	s 2	Unit vector defining direction in which the movable mass travels
Ø	EL2(3)	$ar{\ell}_2$	Position of movable mass (in body 1 coordinates) from c.m. of body 1

Subroutines required: None

Equations programmed:

Discussion: The position of the movable mass is computed from the vector equation  $\vec{l}_2 = \vec{d}_{12} + \vec{s}_{2s}$ .

Segment 3

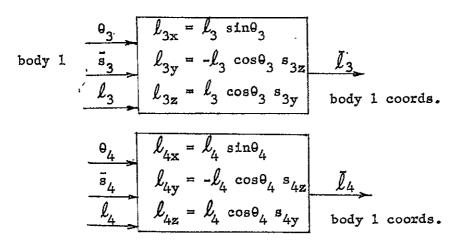
Purpose: To compute the positions of bodies 3 and 4.

Input/output:

I/O	Fortran Name	Math Symbol	Definition
I	тнета3	θ <sub>3</sub>	Angular position of pendulum 3
l I	S3(3)	- 83	Hinge line of pendulum 3
I	PEND3L	$\ell_3$	Scalar length of pendulum 3
ø	EL3(3)	$ar{\mathcal{I}}_3$	Vector position of pendulum 3 from hinge line $s_3$
I	THETA4	. <sub>94</sub>	Angular position of pendulum 4
I	S4(3)	s <sub>4</sub>	Hinge line of pendulum 4 in body 1 coordinated (no dimensions)
I.	PEND4L	$\ell_4$	Scalar length of pendulum 4
ø	EL4(3)	$ar{l}_4$	Vector position of pendulum 4

Subroutines required: None

Equations programmed:



Discussion: None

Segment 4

Purpose: To compute the center of mass equations for bodies 0, 1, 2 and 3. T is defined as the vector distance from the system center of mass to the center of mass of the jth body.

## Input/output:

1/0	Fortran Name	Math Symbol	Definition
I	EL2(3)	$l_2$	Vector position of the movable mass
I	EL3(3)	$ar{m{l}}_3$	Vector position of body 3 from hinge line s <sub>3</sub>
I	EL4(3)	$\mathcal{L}_4$	Vector position of body 4 from hinge line s4
I	D01(3)	ā <sub>01</sub>	Vector distance from the c.m. of body 0 to the hinge line of body 1
I	D13(3)	ā <sub>13</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 3
I	D14(3)	₫ <sub>14</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 4
I	BOMASS	m <sub>O</sub>	Mass of body 0 (slugs)
I	B2MASS	m <sub>2</sub>	Mass of body 2
I	B3MASS	<sup>m</sup> 3	Mass of body 3
I	B4MASS	· <sub>m4</sub>	Mass of body 4
I	TOTMAS	m	Mass of composite body
I		A <sub>1</sub> ,	Coordinate transformation from body 0 to body 1

ø	R1(3)	Ŧ <sub>1</sub>	Vector distance from system c.m. to the c.m. of body 1
Ø	R2(3)	r <sub>2</sub>	Vector distance from the system c.m. to the c.m. of body 2
ø	R3(3)	r̄3	Vector distance from the system c.m. to the c.m. of body 3
Ø	R4(3)	₹ <sub>4</sub> .	Vector distance from the system c.m. to the c.m. of body 4

Subroutines required: None

Equations programmed:

$$\begin{bmatrix} r_{1x} \\ r_{1y} \\ r_{1z} \end{bmatrix} = \frac{m_0}{m} A_1 \quad \begin{bmatrix} d_{01x} \\ d_{01y} \\ d_{01z} \end{bmatrix} - \frac{m_2}{m} \begin{bmatrix} \ell_{2x} \\ \ell_{2y} \\ \ell_{2z} \end{bmatrix} - \frac{m_3}{m} \begin{bmatrix} d_{13x} + \ell_{3x} \\ d_{13y} + \ell_{3y} \\ d_{13z} + \ell_{3z} \end{bmatrix} - \frac{m_4}{m} \begin{bmatrix} d_{14x} + \ell_{4x} \\ d_{14y} + \ell_{4y} \\ d_{14z} + \ell_{4z} \end{bmatrix}$$

$$\begin{bmatrix} r_{2x} \\ r_{2y} \\ r_{2z} \end{bmatrix} = \begin{bmatrix} r_{1x} \\ r_{1y} \\ r_{1z} \end{bmatrix} + \begin{bmatrix} \ell_{2x} \\ \ell_{2y} \\ \ell_{2z} \end{bmatrix}$$

$$\begin{bmatrix} r_{3x} \\ r_{3y} \\ r_{3z} \end{bmatrix} = \begin{bmatrix} r_{1x} \\ r_{1y} \\ r_{1z} \end{bmatrix} + \begin{bmatrix} d_{13x} + \ell_{3x} \\ d_{13y} + \ell_{3y} \\ d_{13z} + \ell_{3z} \end{bmatrix}$$

$$\begin{bmatrix} r_{4x} \\ r_{4y} \\ r_{4z} \end{bmatrix} = \begin{bmatrix} r_{1x} \\ r_{1y} \\ r_{1z} \end{bmatrix} + \begin{bmatrix} d_{14x} + \ell_{4x} \\ d_{14y} + \ell_{4y} \\ d_{14z} + \ell_{4z} \end{bmatrix}$$

$$\begin{bmatrix} r_{4x} \\ r_{4y} \\ r_{4z} \end{bmatrix} = \begin{bmatrix} r_{1x} \\ r_{1y} \\ r_{1z} \end{bmatrix} + \begin{bmatrix} d_{14x} + \ell_{4x} \\ d_{14y} \\ d_{14z} + \ell_{4z} \end{bmatrix}$$

$$\begin{bmatrix} r_{2} \cdot \ell_{3} \cdot \ell_{4} \\ d_{01} \cdot d_{13} \cdot d_{14} \\ d_{14} \cdot d_{14} \end{bmatrix} + \begin{bmatrix} r_{1} \cdot \tilde{r}_{2} \cdot \tilde{r}_{3} \cdot \tilde{r}_{4} \\ \text{(body 1 coords.)} \end{bmatrix}$$

Discussion: None

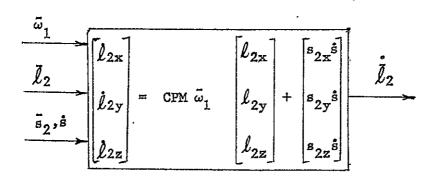
Segment 5  $\label{eq:purpose:to-compute the derivative of $\mathbb{Z}_2$, the rate at which to movable mass in moving.$ 

# Input/output:

1/0	· Fortran Statement	Math Symbol	Definition
I	W1(3)	ω <sub>1</sub>	Angular velocity of body 1
I	EL2(3)	$l_2$	Vector position of the movable mass
I	s2(3)	s	Unit vector defining the direction of travel of the movable mass (body 2)
I	S	s	Movable mass travel, a specified scalar function of time
I	sDOT	ŝ	The time derivative of s.
Ø	EL2DOT(3)	$\dot{I}_2$	The time derivative of $oldsymbol{l}_2$

Subroutines required: SDCALC

## Equations programmed:



where 
$$0 - W1(3) W1(2)$$
  
 $CPM\overline{\omega}_1 = W1(3) 0 - W1(1)$   
 $-W1(2) W1(1) 0$ 

Segment 6

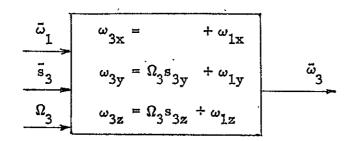
1/2

Purpose: To compute the angular velocity of body 3  $(\tilde{\omega}_3)$ .

I/O	Fortran Name	Math Symbol	Definition
I	W1(3)	$ar{\omega}_1$	Angular velocity of body 1
Ţ	OMEGA3	Ω3	Angular velocity of body 3 about the hinge line s
I	<b>s</b> 3(3)	- s 3	The hinge line about which body 3 rotates
Ø	W3(3)	$\bar{\omega}_3$	The angular velocity of body 3

Subroutines required: None

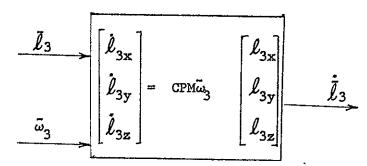
Equations programmed:



I/o	Fortran Name	Math Symbol	Definition
I	EL3(3)	$l_3$	Vector position of body 3 from hinge line s <sub>3</sub>
ľ	W3(3)	ω <sub>3</sub>	Angular velocity of body 3
Ø	EL3DOT(3)	$\dot{l}_3$	Time derivative of $I_3$

Subroutines required: None

Equations programmed:

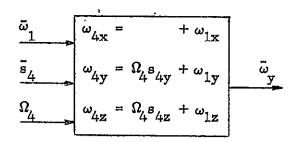


Segment 8  $\label{eq:purpose:the angular velocity of body 4 $\tilde{\omega}_{\!\!\!\!/4}$.}$  Input/output:

1/0	Fortran Name	Math Symbol	Definition
I	W1(3)	$\ddot{\omega}_1$	Angular velocity of body 1
I	OMEGA4	$\dot{\Omega}_{4}$	Angular velocity of body 4 about the hinge line $\frac{1}{5}$
I	s4(3)	<del>.</del> 84	The hinge line about which body 4 rotates
ø	W4(3)	$ar{\omega}_4$	Angular velocity of body 4

Subroutines required: None

### Equations programmed:

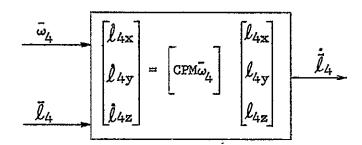


Segment 9  ${\tt Purpose:} \ \ {\tt To \ compute \ the \ derivative \ of \ } {\it L}_4.$ 

I/O	Fortran Name	Math Symbol	Definition
I ·	EL4(3)	$\mathcal{L}_4$	Vector position of body 4 from the hinge line $s_4$
I	W4(3)	$ar{\omega}_4$	Angular velocity of body 4
Ø	KL4DOT(3)	$\dot{ar{\ell}}_4$	Time derivative of $ar{L}_4$

Subroutines required: None

Equations programmed:

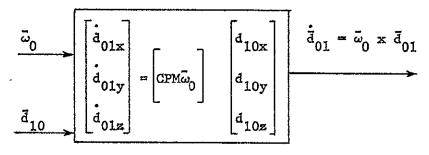


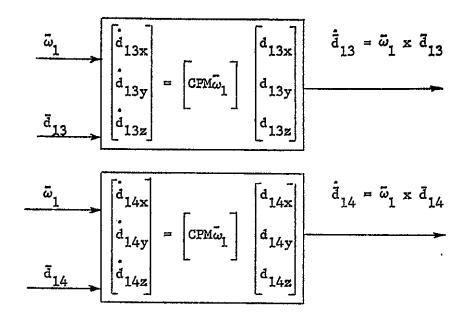
Segment 10  ${\it Purpose:} \quad {\it To compute the time derivatives of $\bar{d}_{01}$, $\bar{d}_{13}$, and $\bar{d}_{14}$. } \\ {\it Input/output:}$ 

I/O	Fortran Statement	Math Symbol	Definition
I	DO1(3)	<sup>∄</sup> 01	Vector distance from the c.m. of body 0 to the hinge line of body 1
I	D13(3)	₫ <sub>13</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 3
I	D14(3)	₫ <sub>14</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 4
·I	W1(3)	$ar{\omega}_1$	Angular velocity of body 1
Ø	D01D0T(3)	₫ <sub>01</sub>	Time derivative of $ar{ ext{d}}_{01}$
ø	D13DOT(3)	ā <sub>13</sub>	Time derivative of $ar{d}_{13}$
Ø	D14DOT(3)	₫ 14	Time derivative of $ar{ ext{d}}_{14}$

Subroutines required: None

### Equations programmed:





Segment 11 Purpose: To compute the time derivatives to the center of mass variables  $\ddot{r}_1$ ,  $\ddot{r}_2$ ,  $\ddot{r}_3$  and  $\ddot{r}_4$ .

1/0	Fortran Statement	Math Symbol	Definition
I	D01D0T(3)	đ 01	Time derivatives of $\bar{d}_{01}$
I	EL2DOT(3)	$\dot{ar{l}}_2$	Time derivative of $ar{l}_2$
I	D13DOT(3)	ā 13	Time derivative of $ar{ extsf{d}}_{13}$
I	EL3DOT(3)	$\dot{l}_3$	Time derivative of ${\cal I}_3$
I	D14DOT(3)	đ	Time derivative of $ar{ ext{d}}_{14}$
I	EL4DOT(3)	$\dot{\mathcal{I}}_4$	Time derivative of $\ell_4$
I	R1DOT(3)	÷1	Time derivative of $ar{ ilde{r}}_1$
I	BOMASS	<sup>m</sup> o	Mass of body 0
I	B2MASS	<sup>m</sup> 2	Mass of body 2
I	B3MASS	<sup>m</sup> 3	Mass of body 3
I	B4MASS	<sup>m</sup> 4	Mass of body 4
I	TOTMAS	m	Mass of composite body (total mass)
I		A <sub>1</sub>	Coordinate transformation from body 0 to body 1
ø	R1DOT(3)	÷1	Time derivative of $\bar{r}_1$
ø	R2DOT(3)	r <sub>2</sub>	Time derivative of $\tilde{r}_2$
Ø	R3DOT(3)	$\dot{\tilde{r}}_3$	Time derivative of $\bar{r}_3$
ø	R4DOT(3)	÷ <sub>4</sub>	Time derivative of $\bar{r}_4$

Subroutines required: None

 $\begin{bmatrix} \dot{t}_{1x} \\ \dot{t}_{1y} \\ \dot{t}_{1z} \end{bmatrix} = \frac{m_0}{m} \begin{bmatrix} \dot{d}_{01x} \\ \dot{d}_{01y} \\ \dot{d}_{01z} \end{bmatrix} - \frac{m_2}{m} \begin{bmatrix} \dot{l}_{2x} \\ \dot{l}_{2y} \\ \dot{l}_{2z} \end{bmatrix} - \frac{m_3}{m} \begin{bmatrix} \dot{d}_{13x} + \dot{l}_{3x} \\ \dot{d}_{13y} + \dot{l}_{3y} \\ \dot{d}_{13y} + \dot{l}_{3z} \end{bmatrix} - \frac{m_4}{m} \begin{bmatrix} \dot{d}_{14x} + \dot{l}_{4x} \\ \dot{d}_{14y} + \dot{l}_{4y} \\ \dot{d}_{14z} + \dot{l}_{4z} \end{bmatrix}$  $\begin{bmatrix} \dot{\mathbf{r}}_{2x} \\ \dot{\mathbf{r}}_{2y} \end{bmatrix} = \begin{bmatrix} \dot{\mathbf{r}}_{1x} \\ \dot{\mathbf{r}}_{1y} \\ \dot{\mathbf{r}}_{1z} \end{bmatrix} + \begin{bmatrix} \hat{\boldsymbol{\ell}}_{2x} \\ \dot{\boldsymbol{\ell}}_{2y} \\ \dot{\boldsymbol{\ell}}_{2z} \end{bmatrix}$  $\begin{bmatrix} \dot{\mathbf{r}}_{3x} \\ \dot{\mathbf{r}}_{3y} \\ \dot{\mathbf{r}}_{3z} \end{bmatrix} = \begin{bmatrix} \dot{\mathbf{r}}_{1x} \\ \dot{\mathbf{r}}_{1y} \\ \dot{\mathbf{r}}_{1z} \end{bmatrix} + \begin{bmatrix} \dot{\mathbf{d}}_{13x} + \dot{\boldsymbol{\ell}}_{3x} \\ \dot{\mathbf{d}}_{13y} + \dot{\boldsymbol{\ell}}_{3y} \\ \dot{\mathbf{d}}_{13z} + \dot{\boldsymbol{\ell}}_{3z} \end{bmatrix}$  $\begin{bmatrix} \dot{\mathbf{r}}_{4x} \\ \dot{\mathbf{r}}_{4y} \\ \dot{\mathbf{r}}_{4z} \end{bmatrix} = \begin{bmatrix} \dot{\mathbf{r}}_{1x} \\ \dot{\mathbf{r}}_{1y} \\ \dot{\mathbf{r}}_{1z} \end{bmatrix} + \begin{bmatrix} \dot{\mathbf{d}}_{14x} + \dot{\mathbf{L}}_{4x} \\ \dot{\mathbf{d}}_{14y} + \dot{\mathbf{L}}_{4y} \\ \dot{\mathbf{d}}_{14z} + \dot{\mathbf{L}}_{4z} \end{bmatrix}.$  $\dot{\bar{d}}_{01}$  (body 0 coordinates)  $\dot{\bar{d}}_{10}$ ,  $\dot{\bar{d}}_{13}$ ,  $\dot{\bar{d}}_{14}$ ,  $\dot{\bar{l}}_{2}$ ,  $\dot{\bar{l}}_{3}$ ,  $\dot{\bar{l}}_{4}$ , (body 1 coordinates)  $\dot{\bar{r}}_{1}$ ,  $\dot{\bar{r}}_{2}$ ,  $\dot{\bar{r}}_{3}$ ,  $\dot{\bar{r}}_{4}$ (body 1 coords;)

Segment 12

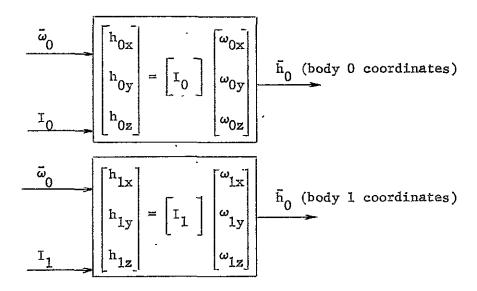
Purpose: To compute the angular momentum of body 0 and body 1.

Input/output:

I/O	. Fortran Name	Math Symbol	Definition ;
I	MO	ت <sub>0</sub> 0	Angular velocity of body 0
I	W1	$ar{\omega}_1$	Angular velocity of body l
I	во́рдої	I <sub>0</sub>	The inertia of body 0
I	BODYlI	I <sub>1</sub>	The inertia of body l
0	но	·ñ <sub>0</sub>	The angular momentum of body 0
0	н1		The angular momentum of body 1

Subroutines required: MULT '

Equations programmed:



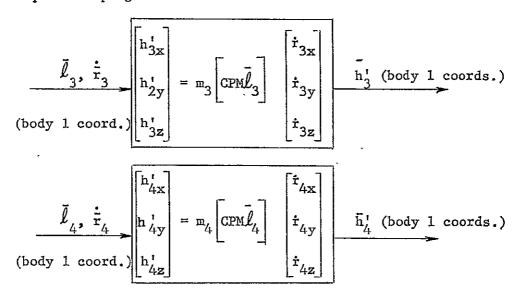
Segment 13 Purpose: To compute the primed angular momentum of bodies 1, 3 and 4.

t/out	put:		
I/O	Fortran Name	Math Symbol	Definition
I	B3MASS	m <sub>3</sub>	The mass of body 3
Ī	EL3(3)	$\bar{\ell}_3$	Vector position of body 3 from the hinge line $\bar{s}_3$
Ι	R3DOT(3)	÷	The time derivative of $\bar{r}_3$
	H3PRIM(3)	$\bar{\mathbf{h}}_{3}^{t}$	The primed angular momentum of body 3
I	B4MASS	<sup>m</sup> 4	The mass of body 4
I	EL4(3)	$ar{m{\ell}}_{4}$	Vector position of body 4 from the hinge line $\bar{s}_4$
I	R4DOT(3)	÷ +	The time derivative of $\bar{r}_4$
0	· H4PRIM(3)	- t 4	The primed angular momentum of body 4
I	H1(3)	ħ <sub>I</sub>	The angular momentum of body 1
I	H3PRIM(3)	ħ'₃	The primed angular momentum of body 3
I	H4PRIM(3)	h4	The primed angular momentum of body 4
I	B2MASS	m <sub>2</sub>	The mass of body 2
I,	EL2(3)	$ar{\ell}_2$	Vector position of the movable mass
I	R2DOT(3)	÷ 2	The time derivative of $ar{ t r}_2$
I	B3MASS	<sup>m</sup> 3	The mass of body 3

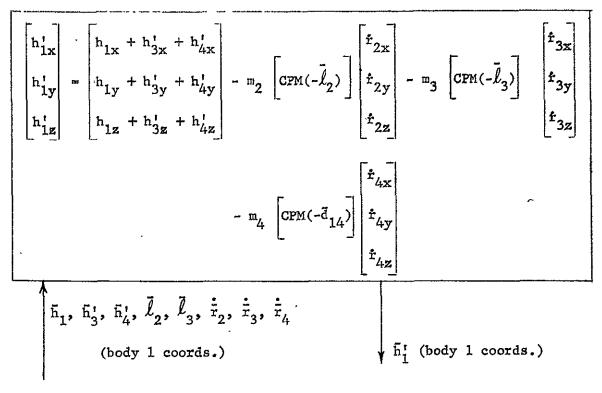
I	R3DOT(3)	÷ <sub>3</sub>	The time derivative of $\ddot{r}_3$ .
I	B4MASS	<sup>m</sup> 4	The mass of body 4
I	R4DOT(3)	<u>.</u> .	The time derivative of $ar{ ext{r}}_4$
I	D13(3)	₫ 13	Vector distance from the c.m. of body 1 to the hinge line of body 3
I	D14(3)	₫ <sub>14</sub>	Vector distances from the c.m. of body 1 to the hinge line of body 4
0	H1PRIM(3)	Б́! 1	The primed angular momentum of body 1

Subroutines required: None

Equations programmed:



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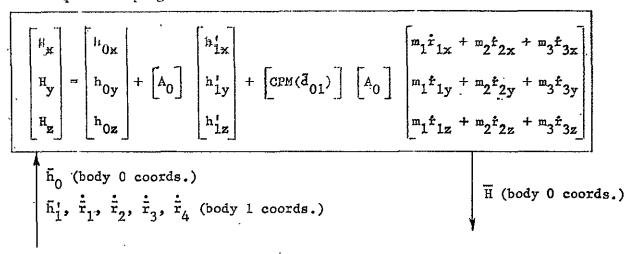
Segment 14

Purpose: To compute the angular momentum of the composite vehicle.

I/O	Fortran Name	Math Symbol	Definition	
I	HO(3)	h <sub>0</sub>	The angular momentum of body 0	
I	h1PRIM(3)	h¦	The primed angular momentum of body	
I	D01(3)	<sup>₫</sup> 01	Vector distance from the c.m. of body 0 to the hinge line of body 1	
I		A <sub>0</sub>	Coordinate transformation from body 1 to body 0	
I	BIMASS	m <sub>1</sub>	Mass of body 1	
I	B2MASS	m <sub>2</sub>	Mass of body 2	
I	B3MASS	<sup>m</sup> 3	Mass of body 3	
I	B4MASS	m <sub>4</sub>	Mass of body 4	
I	RIDOT(3)	÷ <sub>1</sub>	Time derivative of $ ilde{ t r}_1$	
I	R2DOT(3)		Time derivative of $\tilde{r}_2$	
Ţ	R3DOT(3)	$\dot{\bar{r}}_3$	Time derivative of $\bar{r}_3$	
I	R4DOT(3)	r <sub>4</sub>	Time derivative of $\bar{r}_4$	
0	H(3)	ਜ	The angular momentum of the com- posite vehicle	

Subroutines required: None

Equations programmed:



#### Segment 15

Purpose: To compute in body 1 coordinates, the unit vector J. This is done as a matter of computational convenience and is used in setting up the angular momentum derivatives.

#### Input/output:

I/O	Fortran Name	Math Symbol	Definition
I	EL2(3)	$\ell_2$	Vector position of the movable mass
I	D13(3)	ā <sub>13</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 3
I	EL3(3)	$ar{l}_3$	Vector position of body 3
Ι	D14(3)	₫ <sub>14</sub>	Vector distance from the c.m. of body 1 to the hinge line of body 4
I	EL4(3)	$ar{\ell}_{4}$	Vector position of body 4
I	BMASS2	m <sub>2</sub>	Mass of body 2
I	BMASS3	m <sub>3</sub>	Mass of body 3
I	BMASS4	m <sub>4</sub>	Mass of body 4
0	AJ1(3)	j <sub>1</sub>	Unit vector defined in body 1

Subroutines required: None

Equations programmed:  $\frac{\vec{l}_{2}, \vec{l}_{3}, \vec{l}_{4}}{\underbrace{\frac{m_{2}, m_{3}, m_{4}}{\vec{d}_{13}, \vec{d}_{14}}} } \begin{bmatrix} j_{1x} \\ j_{1y} \end{bmatrix} = \underbrace{m_{2}} \begin{bmatrix} l_{2x} \\ l_{2y} \\ l_{2z} \end{bmatrix} + \underbrace{m_{3}} \begin{bmatrix} d_{13x} + l_{3x} \\ d_{13y} + l_{3y} \\ d_{13z} + l_{3z} \end{bmatrix} + \underbrace{m_{4}} \begin{bmatrix} d_{14x} + l_{4x} \\ d_{14y} + l_{4y} \\ d_{14z} + l_{4z} \end{bmatrix} \underbrace{j_{1}}_{\text{(body 1 coords.)}}$ 

Segment 16

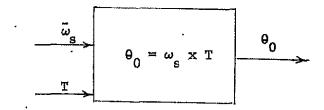
Purpose: To update the orbit angle  $\boldsymbol{\theta}_0$  and to compute the external forces and moments.

### Input/output:

I/O	Fortran Name	Math Symbol	Definition
I	TIME	T	The time in seconds
I	Ws	ω s	The orbital rate
0	THETO	θ <sub>0</sub>	The orbital angular position
0	TQ1G(3)	TQ <sub>1G</sub>	The gravity gradient torques
0	TQ1P(3)	TQ <sub>1P</sub>	The propulsion torques

Subroutines required: GGRAD, PCON

### Equations programmed:



Segment 17

Purpose: To sum to forces and moments acting on bodies 0 and 1.

I/O	Fortran Name	Math Symbol	Definition
I	F01(3)	F <sub>01</sub>	Force acting on body 0 due to gravity gradient
I	F11(3)	F <sub>11</sub>	Force acting on body 1 due to gravity gradient
I	TQ0G(3)	TQ <sub>OG</sub>	The torque acting on body 0 due to gravity gradient
I	TQ0P(3)	TQOP	The torque acting on body 0 due to propulsion forces
I	TQ1G(3)	TQ <sub>IG</sub>	The torque acting on body l due to gravity gradient
I	TQ1P(3)	TQ <sub>lp</sub>	The torque acting on body 1 due to propulsion forces
Ø	TOEF(3)	T <sub>0eF</sub>	The summation of the torques acting on body 0
ø	T1EF(3)	TleF	The summation of the torques acting on body 1

Subroutines required: None

Equations programmed:

Segment 18

Purpose: To calculate the time derivatives of the angular momentum of the composite vehicle.

	ac/oachac.				
	1/0	Fortran Name	Math Symbol	Definition ;	
	I	WO(3)	$ar{\omega}_{ m O}$	Angular velocity of body 0	
	I	H(3)	Ħ	Angular momentum of the composite body	
	I	TOTMAS	m	Mass of the composite body	
,	I	BOMASS	<sup>m</sup> o	Mass of body 0	
	I	D01(3)	ā <sub>01</sub>	Vector distance from the c.m. of body 0 to the hinge line of body 1	
	I .	AJ1(3)	ī <sub>1</sub>	A vector, defined in body 1 coordinates used only for computational convenience	
	I	F0(3)	F <sub>0</sub>	Summation of the forces acting on body 0	
			<sup>A</sup> 0	Coordinate transformation from body 1 to body 0	
	I	TOEF(3)	T <sub>OEF</sub>	Summation of the torques acting on body 0	
	ı ʻ	T1EF(3)	T <sub>1EF</sub>	Summation of the torques acting on body 1	
	0	HDOT(3)	dH dt	The time derivative of H	

Subroutines required: None

Equations programmed:  $\begin{bmatrix} \frac{dH_{x}}{dt} \\ \frac{dH_{y}}{dt} \\ \frac{dH_{y}}{dt} \\ + & CPM( - 0 ) \end{bmatrix} = \frac{1}{m} \begin{bmatrix} GPM \\ (m_{0}-m) \end{bmatrix} \begin{bmatrix} d_{01x} \\ d_{01y} \\ d_{01z} \end{bmatrix} - A_{0} \begin{bmatrix} j_{1x} \\ j_{1y} \\ k_{01z} \end{bmatrix} \begin{bmatrix} F_{0x} \\ F_{0y} \\ k_{01z} \end{bmatrix} = \frac{1}{m} \begin{bmatrix} d_{01x} \\ d_{01y} \\ k_{01z} \end{bmatrix} - \begin{bmatrix} f_{1x} \\ f_{1y} \\ k_{1y} \end{bmatrix} + \begin{bmatrix} T_{0EFx} \\ T_{0EFy} \\ k_{1z} \end{bmatrix} + A_{0} \begin{bmatrix} T_{1EFx} \\ T_{1EFy} \\ T_{1EFz} \end{bmatrix}$   $\begin{bmatrix} \tilde{\omega}_{0}, \ \tilde{H}, \ \tilde{F}_{0}, \ \tilde{T}_{0EF}, \ \tilde{d}_{01} \ (body \ 0 \ coords.) \\ \tilde{J}_{1}, \ F_{1}, \ T_{1EF} \end{bmatrix} = (body \ 1 \ coords.)$   $\begin{bmatrix} \tilde{d}_{1x} \\ \tilde{d}_{1y} \\ \tilde{d}_{1z} \end{bmatrix} = \begin{bmatrix} \tilde{d}_{01x} \\ \tilde{d}_{1x} \\ \tilde{d}_{1x} \end{bmatrix} = \begin{bmatrix} \tilde{d}_{01x} \\ \tilde{d$ 

Discussion: The following vector equation is programmed in this segment:

$$\frac{d\overline{H}}{dt} + \overline{\omega}_0 \times \overline{H} = \left\{ -(m-m_0)^{\overline{d}}_{01} - \overline{J}_2 \right\} \times \frac{\overline{F}_0}{m} + \left\{ m_0^{\overline{d}}_{01} - \overline{J}_1 \right\} \times \frac{\overline{F}_0}{m} + \overline{T}_{0EF} + \overline{T}_{1EF}$$

Segment 19 Purpose: To calculate the time derivative of  $h_1^i$  about the unconstrained axis  $\underline{x}_1$  .

1/0	Fortran Name	Math Symbol	Definition
I	W1(3)	$\bar{\omega}_1$	Angular velocity of body l
I	HIPRIM(3)	ħ <sub>1</sub>	The primed angular momentum of body 1
I	B2MASS	™2	Mass of body 2
I	EL2DOT(3)	$\dot{\tilde{L}}_2$	Time derivative of $ar{\ell}_2$
I	R2DOT(3)	÷2	Time derivative of $\bar{r}_2$
I	B3MASS	m <sub>3</sub>	Mass of body 3
I	D13DOT(3)	ā <sub>13</sub>	Time derivative of $\bar{d}_{13}$
I	EL3DOT(3)	$\bar{\ell}_3$	Time derivative of $ar{ar{\ell}}_3$
I	R3DOT(3)	r <sub>3</sub>	Time derivative of $\vec{r}_3$
I	B4MASS	m <sub>4</sub> .	Mass of body 4
I	D14DOT(3)	id 14 id 4	Time derivative of d <sub>14</sub>
I	EL4DOT(3)	$\bar{\ell}_4$	Time derivative of $ar{\ell}_4$
ı	R4DOT(3)	÷ 4	Time derivative of $\bar{r}_4$
I	AJ1(3)	jī	A vector, defined in body 1 coordinates, used for computational convenience
I	Tlef(3)	Tlef	Summation of the torques acting on body 1
I	T01	<b>T</b> 0→1	The torque acting between bodies 0 and 1
0	H1PDOT(1)	ĥ' <sub>1x</sub>	Time derivative of h

Subroutines required: TORKO1

Equations programmed:

Unconstrained component along  $\bar{x}_0 = \bar{x}_1$  (axis)

$$\frac{dh_{1x}^{'}}{dt} + \omega_{1y}h_{1z}^{'} - \omega_{1z}h_{1y}^{'} = \dot{r}_{1y} (-m_{2}\dot{l}_{2z} - m_{3} (\dot{d}_{13z} + \dot{l}_{3z}) - m_{4} (\dot{d}_{14z} + \dot{l}_{4z})$$

$$- \dot{r}_{1z} (-m_{2}\dot{l}_{2y} - m_{3} (\dot{d}_{13y} + \dot{l}_{3y}) - m_{4} (\dot{d}_{14y} + \dot{l}_{4y})$$

$$+ \dot{j}_{1y} (\frac{f_{0y}}{m} \sin\theta_{1} - \frac{f_{0z}}{m} \cos\theta_{1}) + \dot{j}_{1z} (\frac{f_{0y}}{m} \cos\theta_{1} + \frac{f_{0z}}{m} \sin\theta_{1})$$

$$+ \dot{j}_{1z} \frac{f_{1y}}{m} - \dot{j}_{1y} \frac{f_{1z}}{m} + T_{1EFx} + T_{(0 \longrightarrow 1)x}$$

$$\dot{h}_{1}^{'}, \, \dot{\omega}_{1}, \, \dot{\dot{r}}_{1}, \, \dot{\dot{r}}_{2}, \, \dot{\dot{r}}_{3}, \, \dot{\dot{r}}_{4}, \, \dot{\dot{l}}_{2}, \, \dot{\dot{l}}_{3}, \, \dot{\dot{l}}_{4}, \, \dot{\bar{j}}_{1}, \, \bar{f}_{1}, \, \bar{T}_{1EF}, \, \bar{T}_{(0 \longrightarrow 1)x}$$

$$(body \ 1 \ coords.)$$

h'lx-(body l coords.)

Sagment 20 Purpose: To calculate the time derivatives of the primed angular momenta about the unconstrained axes  $s_3$  and  $s_4$ .

1/0	Fortran Name	Math Symbol	Definition
I	H3PRIM(3)	Б <u>'</u>	The primed angular momentum of body 3
ľ	S3(3)	- s <sub>3</sub>	The hinge line of body 3
I	W1(3)	ω <sub>1</sub>	The angular velocity of body 1
I	B3MASS	m <sub>3</sub>	Mass of body 3
I	EL3DOT(3)	$ar{l}_3$	Time derivative of $ar{l}_3$
. I	R3DOT(3)	<sup>m</sup> 3 ℓ 3 ⋮ 3 ℓ 3	Time derivative of $\bar{r}_3$
I	EL3(3)	$ar{\ell}_3$	Vector position of body 3 from the hinge line s <sub>3</sub>
I	B4MASS	<sup>m</sup> 3	Mass of body 4
I	TOTMAS	m	Mass of composite vehicle
I	F0(3)	₹o	Summation of the forces acting on body 0
Ι	F1(3)	F <sub>1</sub>	Summation of the forces acting on body 1
I	T13	<u>T</u> 1 <b>→</b> 3	Torque acting between bodies 1 and 3
ø	G3DOT dt	$(\bar{h}_3^! \cdot \bar{s}_3)$	Time derivative of the unconstrained component of $\bar{h}_3^{\prime}$
I	H4PRIM(3)	ñ' <sub>4</sub>	The primed angular momentum of body 4

				<u> </u>
	I	S4(3)	8.4	The hinge line of body 4
	I	EL4DOT(3)	$\bar{l}_4$	Time derivative of $ar{\ell}_4$
1	I	R4DOT(3)	÷4	Time derivative of $\vec{r}_4$
	I	EL4(3)	ř <sub>4</sub> Į <sub>4</sub>	Vector position_of body 4 from the hinge line s4
	I	т14	<u>T</u> 1→4	Torque acting between bodies 1 and 4
-	0	G4DOT dt	(ñ <u>'</u> . • \$ 4)	Time derivative of the unconstrained component of $ar{h}_4^*$

Subroutines required: TORK13, TORK14

Equations programmed:

$$\frac{d}{dt} (\tilde{h}_{3}^{'}, \tilde{s}_{3}) + s_{3y} (\omega_{1z}h_{3x}^{'} - \omega_{1x}h_{3z}^{'}) + s_{3z} (\omega_{1x}h_{3y}^{'} - \omega_{1y}h_{3x}^{'}) =$$

$$m_{3}s_{3y} (\hat{l}_{3z}\hat{s}_{3x} - \hat{l}_{3x}\hat{s}_{3z}) + m_{3}s_{3z} (\hat{l}_{3x}\hat{s}_{3y} - \hat{l}_{3y}\hat{s}_{3x})$$

$$+ \frac{m_{3}}{m} s_{3y} \hat{l}_{3z} (F_{0x} + F_{1x}) - \hat{l}_{3x} (-F_{0y}sin\theta_{1} + F_{0z}cos\theta_{1} + F_{1z})$$

$$+ \frac{m_{3}}{m} s_{3z} \hat{l}_{3z} (F_{0y}cos\theta_{1} + F_{0z}sin\theta_{1} + F_{1y}) - \hat{l}_{3y} (F_{0x} + F_{1x})$$

$$\frac{d(\tilde{h}_{4}^{'}, \tilde{s}_{4}^{'})}{dt} + s_{4y} (\omega_{1z}h_{4x}^{'} - \omega_{1x}h_{4z}^{'}) + s_{4z} (\omega_{1x}h_{4y}^{'} - \omega_{1y}h_{4x}^{'})$$

$$= m_{4}s_{4y} (\hat{l}_{4z}\hat{t}_{4x} - \hat{l}_{4x}\hat{t}_{4z}) + m_{4}s_{4y} (\hat{l}_{4x}\hat{t}_{4y} - \hat{l}_{4y}x_{4x})$$

$$+ \frac{m_{4}}{m} s_{4y} \hat{l}_{4z} (F_{0x} + F_{1x}) - \hat{l}_{4x} (-F_{0y}sin\theta_{1} + F_{0z}cos\theta_{1} + F_{1z})$$

$$+ \frac{m_{4}}{m} s_{4z} \hat{l}_{4x} (F_{0y}cos\theta_{1} + F_{0z}sin\theta_{1} + F_{1y}) - \hat{l}_{4y} (F_{0x} + F_{1x}) + T_{1+4}$$

$$\tilde{\omega}_{1}, \tilde{h}_{3}^{'}, \tilde{h}_{4}^{'}, \tilde{l}_{3}, \tilde{l}_{4}, \tilde{l}_{3}, \tilde{l}_{4}$$

$$\tilde{x}_{3}, \tilde{x}_{4}, \tilde{x}_{1}, \tilde{x}_{1}, \tilde{x}_{1}, \tilde{x}_{3}, \tilde{l}_{4}$$

$$\tilde{w}_{1}, \tilde{h}_{3}^{'}, \tilde{h}_{4}^{'}, \tilde{l}_{3}, \tilde{l}_{4}, \tilde{l}_{3}, \tilde{l}_{4}$$

$$\tilde{w}_{2}, \tilde{h}_{3}, \tilde{h}_{4}^{'}, \tilde{l}_{3}, \tilde{l}_{4}$$

$$\tilde{w}_{3}, \tilde{h}_{4}^{'}, \tilde{h}_{4}, \tilde{l}_{3}, \tilde{l}_{4}$$

$$\tilde{w}_{3}, \tilde{h}_{4}^{'}, \tilde{h}_{4}, \tilde{h}_{3}, \tilde{h}_{4}^{'}, \tilde{h}_{4}, \tilde{h}_{3}, \tilde{h}_{4}$$

$$\tilde{w}_{3}, \tilde{h}_{4}^{'}, \tilde{h}_{5}, \tilde{h}_{4}^{'}, \tilde{h}_{5}, \tilde{h}_{4}^{'}, \tilde{h}_{5}, \tilde{h}_{4}^{'}, \tilde{h}_{5}, \tilde{h}_{5}^{'}, \tilde{h}_{5}, \tilde{h}_{5}^{'}, \tilde{h}_{5}, \tilde{h}_{5}^{'}, \tilde{h}_{5}, \tilde{h}_{5}, \tilde{h}_{5}, \tilde{h}_{5}, \tilde{h}_{5}, \tilde{h}_{5}, \tilde{h}_{5}, \tilde{h}_{5}, \tilde{h}_{5},$$

Discussion: None

(body 1 coords.)